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Five hundred and fifty-fourth Meeting.

August 9, 1865. — STATUTE MEETING.

The RECORDING SECRETARY in the chair.

The following memoirs were presented by title: —

I. *Examination of a Hydrocarbon-Naphtha, obtained from the Products of the Destructive Distillation of Lime Soap.* By C. M. WARREN and F. H. STORER.

II. *Examination of Naphtha from Rangoon Petroleum.* By C. M. WARREN and F. H. STORER.

Five hundred and fifty-fifth Meeting.

September 12, 1865. — ADJOURNED STATUTE MEETING.

The PRESIDENT in the chair.

The President called the attention of the Academy to the recent decease of three of its members: Mr. George Livermore, the Treasurer of the Academy; Bishop Alonzo Potter of Pennsylvania, of the Associate Fellows; and Sir William Jackson Hooker, of the Foreign Honorary Members.

Mr. Ferrel made the following communication on certain Formulæ of Interpolation.

The necessity of frequent interpolations in almost all kinds of computations renders it important that the most convenient formulæ possible should be devised for that purpose. The following formulæ are especially designed to facilitate interpolations where a number of them are to be made at equal intervals between values of a function given or computed for equal intervals of the variable: —

Let F_x be any function of x, given or computed, for the equal intervals of $x = -\omega$, $x = 0$, $x = \omega$, $x = 2\,\omega$, &c., and let Δ^1, Δ^2, Δ^3, &c. express the different orders of finite differences. By writing $\Delta_{/}^1$ for $\frac{1}{2}(\Delta^1_{-\frac{1}{2}} + \Delta^1_{\frac{1}{2}}) = \Delta_{\frac{1}{2}}^1 - \frac{1}{2}\Delta_0^2$, $\Delta_{/}^3$ for $\frac{1}{2}(\Delta^3_{-\frac{1}{2}} + \Delta^3_{\frac{1}{2}}) = \Delta_{\frac{1}{2}}^3 - \frac{1}{2}\Delta_0^4$, &c., we have,

$$(1.)\qquad F_x = F_0 + A_1 x + A_2 x^2 + A_3 x^3 \,.\;.\;.\;.\;.$$

in which

$$A_1 = \frac{1}{\omega}\left(\Delta_{/}^1 - \tfrac{1}{6}\Delta_{/}^3 + \tfrac{1}{30}\Delta_{/}^5 - \tfrac{1}{140}\Delta_{/}^7 \,.\;.\;.\;.\;.\right)$$

$$A_2 = \frac{1}{2\cdot\omega^2}\left(\Delta_0^2 - \tfrac{1}{12}\Delta_0^4 + \tfrac{1}{90}\Delta_0^6 - \tfrac{1}{560}\Delta_0^8 \,.\;.\;.\;.\;.\right)$$

$$A_3 = \frac{1}{2\cdot 3\cdot\omega^3}\left(\Delta_{/}^3 - \tfrac{1}{4}\Delta_{/}^5 + \tfrac{7}{120}\Delta_{/}^7 \,.\;.\;.\;.\;.\right)$$

$$(2.)\quad A_4 = \frac{1}{2\cdot 3\cdot 4\cdot\omega^4}\left(\Delta_0^4 - \tfrac{1}{6}\Delta_0^6 + \tfrac{1}{48}\Delta_0^8 \,.\;.\;.\;.\;.\right)$$

$$A_5 = \frac{1}{2\cdot 3\cdot 4\cdot 5\cdot\omega^5}\left(\Delta_{/}^5 - \tfrac{1}{3}\Delta_{/}^7 \,.\;.\;.\;.\;.\right)$$

$$A_6 = \frac{1}{2\cdot 3\cdot 4\cdot 5\cdot 6\cdot\omega^6}\left(\Delta_0^6 - \tfrac{1}{4}\Delta_0^8 \,.\;.\;.\;.\;.\right)$$

$$A_7 = \frac{1}{2\cdot 3\cdot 4\cdot 5\cdot 6\cdot 7\cdot\omega^7}\left(\Delta_{/}^7 \,.\;.\;.\;.\;.\right)$$

. . . . .

The preceding formula may be used for interpolating F_x for any value of x positive or negative within a certain range, but the greater the value of x the greater the effect of the neglected orders of differences upon the interpolated numbers, and if i orders of differences are used, it may become quite inaccurate if x is taken greater than $\frac{1}{2}\,i\,\omega$. If the value of x is confined within the limits of $\mp\frac{1}{2}\,\omega$, instead of the preceding formula, we may use the following of only four variable terms without sensible error: —

$$F_x = F_0 + B_1 x + B_2 x^2 + B_3 x^3 + B_4 x^4, \tag{3.}$$

in which

$$\begin{aligned} B_1 &= \frac{1}{\omega}\left(\Delta_{,}^{1} - \tfrac{1}{6}\Delta_{,}^{3} + \left(\tfrac{1}{30} - \tfrac{1}{256} \text{ of } \tfrac{1}{30}\right)\Delta_{,}^{5} - \tfrac{1}{140}\Delta_{,}^{7} \ldots\ldots\right), \\ B_2 &= \frac{1}{2\cdot\omega^2}\left(\Delta^2 - \tfrac{1}{12}\Delta^4 + \tfrac{1}{90}\Delta^6 \ldots\ldots\right), \\ B_3 &= \frac{1}{2\cdot 3\cdot\omega^3}\,\Delta_{,}^{3} - \left(\tfrac{1}{4} - \tfrac{1}{16} \text{ of } \tfrac{1}{4}\right)\Delta_{,}^{5} + \tfrac{1}{19}\Delta_{,}^{7} \ldots\ldots), \\ B_4 &= \frac{1}{2\cdot 3\cdot 4\cdot\omega^4}\left(\Delta^4 - \tfrac{1}{6}\Delta^6 \ldots\ldots\right), \end{aligned} \tag{4.}$$

and in which the maximum possible error E of any interpolated number arising from neglected terms is only

$$E = \pm\left(\tfrac{1}{374000}\Delta_{,}^{5} - \tfrac{1}{82000}\Delta^6 - \tfrac{1}{108000}\Delta_{,}^{7} \ldots\ldots\right). \tag{5.}$$

The constants B_1, B_2, &c. are so determined as to make the two preceding expressions of F_x correspond for the four values of $x = \mp \frac{1}{4}\omega$, and $x = \mp \frac{1}{2}\omega$; so that, corresponding at equal intervals of $\frac{1}{4}\omega$, they cannot differ much for any intermediate value of x, as is shown by (5). The advantage of this last formula over the preceding is, that with only four terms containing the variable you have nearly all the accuracy of seven or eight terms of the former. But it can only be used within the limit of $\frac{1}{2}\omega$ before and after F_0; so that in interpolating it requires the constants B_1, B_2, &c. to be computed for every interval or given value of F_x.

As the unit of x is arbitrary, when the interpolations are made at equal intervals it can be taken equal to one of the equal parts of x corresponding to the interpolated values of F_x, and then ω will represent the number of interpolated intervals contained in one of the original intervals; that is, $\omega - 1$ will represent the number of interpolations in each original interval. In this case the value of x used in interpolating is always one of the numbers ∓ 1, ∓ 2, ∓ 3, &c.; and if the number of interpolations to each original interval is not too great, the different terms in the expression of F_x are readily obtained after the constants B_1, B_2, &c. have been computed.

For all cases in which the value of x does not exceed 6, that is, in which ω does not exceed 12, the preceding formula may be put into a form still more convenient for interpolating. The preceding expression of F_x for all values of x from -6 to $+6$ gives

$$\left.\begin{array}{l} F_{\mp 6}=6\\ F_{\mp 5}=5\\ F_{\mp 4}=4\\ F_{\mp 3}=3\\ F_{\mp 2}=2\\ F_{\mp 1}=1 \end{array}\right\} \mp B_1 + 4\,B_2 \mp 16\,B_3 + 64\,B_4 \left.\begin{array}{r} +12\\ +5\\ 0\\ -3\\ -4\\ -3 \end{array}\right\} B_2 \mp 6\,B_3 + 28\,B_4$$

$$\left.\begin{array}{r} +16\\ +5\\ 0\\ -1\\ 0\\ +1 \end{array}\right\} \mp 3\,B_3 + 36\,B_4 \left.\begin{array}{r} 0\\ -5\\ 0\\ +3\\ 0\\ -5 \end{array}\right\} 3\,B_4 + F_0.$$

This again may be transformed into the following form: —

$$(6.)\quad \left.\begin{array}{l} F_{\mp 6}\\ F_{\mp 5}\\ F_{\mp 4}\\ F_{\mp 3}\\ F_{\mp 2}\\ F_{\mp 1} \end{array}\right\} = F_0 \left.\begin{array}{r} +6\\ +5\\ +4\\ +3\\ +2\\ +1 \end{array}\right\} (\mp A + B) \left.\begin{array}{r} +12\\ +5\\ 0\\ -3\\ -4\\ -3 \end{array}\right\} (B' \mp C) \left.\begin{array}{r} +16\\ +5\\ 0\\ -1\\ 0\\ +1 \end{array}\right\} \mp (\tfrac{1}{2}C + D) \left.\begin{array}{r} 0\\ -5\\ 0\\ +3\\ 0\\ -5 \end{array}\right\} \tfrac{1}{12}D,$$

in which

$$A = \frac{1}{\omega}\left\{\Delta_{,}^{1} - \left(\frac{1}{6} - \frac{8}{3\,\omega^2}\right)\Delta_{,}^{3} + \left(\frac{1}{30} - \frac{1}{256}\cdot\frac{1}{30} - \frac{5}{8\,\omega^2}\right)\Delta_{,}^{5} - \left(\frac{1}{140} - \frac{1}{7\,\omega^2}\right)\Delta_{,}^{7} \ldots\ldots\right\}$$

$$(7.)\quad B = \frac{1}{\omega^2}\left\{2\,\Delta^2 - \left(\frac{1}{6} - \frac{8}{3\,\omega^2}\right)\Delta^4 + \frac{1}{45}\,\Delta^6 \ldots\ldots\right\}$$

$$C = \frac{1}{\omega^3}\left\{\Delta_{,}^{3} - \left(\frac{1}{4} - \frac{1}{16}\text{ of }\frac{1}{4}\right)\Delta_{,}^{5} + \frac{1}{19}\,\Delta_{,}^{7} \ldots\ldots\right\}$$

$$D = \frac{1}{\omega^4}\left\{\frac{3}{2}\,\Delta^4 - \frac{1}{4}\,\Delta^6 \ldots\ldots\right\}$$

$$B' = \frac{1}{4}\,B + \frac{1}{2\,\omega^4}\,\Delta^4 - \frac{7}{36\,\omega^4}\,\Delta^6 \ldots\ldots\Big\}$$

and in which the minus sign must be used for interpolated values of F_x preceding F_0, and the plus sign for those following F_0. In the latter transformations no small terms have been omitted; so that this last form is of the same degree of accuracy as the preceding one, and

it is so arranged that there are only four multiplications of the constants to be performed by numbers which are small and convenient for that purpose, in order to obtain any one of the interpolated values of F_x, whereas in the preceding form there are for the most part ten, the number being equal to the sum of the exponents of x in (3). This formula is accurate for all cases in which it is necessary to use eight orders of differences, and in all ordinary cases in which it is necessary to use only four or five orders of differences it is quite simple. In general, it is only necessary to compute the three constants A, B, and C, using $\frac{1}{4}B$ for B', for even then the maximum possible error is only of the order $\frac{1}{1440}\Delta^4$. This formula is applicable in all cases in which the number of interpolations does not exceed twelve. If we wish to interpolate to twelfths, ω in the expression of the preceding constants A, B, C, &c. must be put equal to 12; if to tenths, equal to 10; and so for any other number. If we interpolate to twelfths, we must use (6) from F_{-6} to F_{+6}; if to tenths, from F_{-5} to F_{+5}; and so on. In this way we get the middle interpolated number from two sets of constants; first, by going forward from F_0, and secondly, by going back from F_ω, which is the F_0 in the formula belonging to the next set of constants. This furnishes a very good check for the accuracy of the interpolations in addition to that of the regularity of the differences. In cases in which ω is less than twelve, the formula from F_{-6} to F_{+6} would give several of the middle interpolations in duplicate, but it is unnecessary to take it so as to have more than one.

In interpolating to sixths, it is evident that, instead of putting ω equal to six, and using the formula from F_{-3} to F_{+3}, we can put it equal to twelve, and use only the functions of F with even subscript numbers from F_{-6} to F_{+6}. By so doing, we have the advantage of using the functions $F_{\mp 4}$ and $F_{\mp 2}$, which are very simple, since three of numerical coefficients are ciphers in $F_{\mp 4}$, and two of them in $F_{\mp 2}$. By putting $\omega = 10$, and using these same functions of x, we have a very convenient formula for interpolating to fifths; but it does not give any one of the interpolations in duplicate as a check, which, perhaps, is always unnecessary where the number of interpolations is so small, the regularity of the differences being a sufficient check. Also, in interpolating to fourths, instead of putting $\omega = 4$ and using $F_{\mp 2}$ and $F_{\mp 1}$, we can put $\omega = 12$, and use $F_{\mp 6}$ and $F_{\mp 3}$; but it is much better to put $\omega = 8$, and use $F_{\mp 4}$ and $F_{\mp 2}$, which, for reasons already stated, are much more simple. In interpolating to thirds we can

put $\omega = 12$ and use $F_{\mp 4}$, which comprises only the two constants A and B, and hence is very simple.

As an example of the application of the preceding formula, let it be required to interpolate the moon's Right Ascension to twelfths, that is, to every second hour, having the Right Ascension and the differences given for each day at noon, as follows: —

1867.	R. A.	Δ^1	Δ^2	Δ^3	Δ^4	Δ^5	Δ^6
d.	h. m. s.	m. s.	s.	s.	s.	s.	s.
Ap. 1	21 59 38.64	+50 46.58	+23.84	+18.97	+6.09	—2.22	—1.62
2	22 50 25.22	51 29.39	42.81	22.84	3.87	3.75	1.53
3	23 41 54.61	52 35.04	65.65	22.96	0.12	5.68	1.93
	.	.	.	. .	.	.	

With these differences we get from (7), putting $\omega = 12$,

$-A+B$	$A+B$	$B'-C$	$B'+C$	$-\frac{1}{2}C+D$	$+\frac{1}{2}C+D$
m. s.	m. s.				
—4 12.3637	+4 13.0129	+.0719	+.0907	—.0043	+.0051
—4 14.8104	4 15.9910	.1354	.1604	.0059	.0065
.	.	.	.	.	

With these values (6) gives the following, in which the first column contains the multiples of a few of the last places of $-A+B$ and $A+B$, or of their complements, when the multiples are negative, the second, the multiples of $B'-C$ and $B'+C$, or of their complements when the multiples are negative; and so on.

				R. A.	Δ^1	Δ^2
				h. m. s.	m. s.	s.
.818	.863	.931	F_{-6}	21 34 25.25	4 11.91	
.181	.359	.978	F_{-5}	21 38 37.16	4 12.03	.12
.545			F_{-4}	21 42 49.19	4 12.15	.12
.904	.784	.004	F_{-3}	21 47 01.34	4 12.29	.14
.273	.712		F_{-2}	21 51 13.63	4 12.43	.14
.6363	.784	.996	F_{-1}	21 55 26.06	4 12.58	.15
.0129	.728	.005	F_0	21 59 38.64	4 12.75	.17
.026	.637		F_1	22 3 51.39	4 12.91	.16
.039	.728	.995	F_2	22 8 4.30	4 13.10	.19
.052			F_3	22 12 17.40	4 13.29	.19
.065	.453	.025	F_4	22 16 30.69	4 13.49	.20

				R. A.	Δ^1	Δ^2
				h. m. s.	m. s.	s.
.077	.088	.032	F_5	22 20 44.18	4 13.71	.22
.138	.625	.904	F_6	22 24 57.89	.93	.22
.948	.677	.970	F_{-5}	.82	.16	.23
.758			F_{-4}	.98	.41	.25
.569	.594	.006	F_{-3}	.39	.67	.26
.379	.458		F_{-2}	.06	.94	.27
.1896	.594	.994	F_{-1}	.00	.22	.28
.9910	.519	.006	F_0	22 50 25.22	.52	.30
.982	.358		F_1	.74	.82	.30
.973	.519	.994	F_2	.56	.14	.32
.964			F_3	.70	.48	.34
.955	.802	.032	F_4	.18	.83	.35
.946	.925	.104	F_5	.01	.18	.35
. . .	. . .	. . .	F_6	.19	. .	. .
			. .	. .		

In this example the part of the formula (6) depending upon $\frac{1}{12} D$ is insensible. By combining the decimal part .640 of F_0 in the first group with the first three columns, we get the decimal part of F_x from F_{-6} to F_6. Thus $.640 + .818 + .863 + .931 = .252$, only the first two decimals of which need be written down; also $.640 + .181 + .359 + .978 = .158$, for which .16 is written; and so on. From F_0 to F_6 the resulting sum of the numbers is written in the line beneath the one in which the numbers are written. The two lines in brackets, the first combined with the decimal part of F_0 in the first group, the second with that of F_0 in the second group, both give F_6, which is also F_{-6} of the second group. A check for the accuracy of the interpolation, as has been stated, is that these should give the same result. The last two figures of the interpolated numbers being thus obtained, and also their differences, as represented in the second group, after the initial differences of the first group only are once obtained, the remaining part of the interpolated numbers is readily filled in, as represented in the first group of the preceding example.

As a second example, let it be required to interpolate the preceding Right Ascensions to fourths. Putting $\omega = 8$ in (7), we get from the given differences

$-A+B$	$A+B$	$B'-C$	$B'+C$
m. s.	m. s.	s.	s.
—6 18.3465	6 19.8119	0.1522	0.2156
—6 21.8330	6 24.4922	0.2910	0.3748

With these values (6) gives

			R. A.	Δ^1	Δ^2
			h. m. s.	m. s.	s.
.614	.000	F_{-4}	21 34 25.25	12 36.09	
.307	.391	F_{-2}	21 47 1.34	12 37.30	1.21
.623	.138	F_0	21 59 38.64	12 38.76	1.46
.248	.000	F_2	22 12 17.40	12 40.49	1.73
.668	.000	F_4	22 24 57.89	12 42.50	2.01
.334	.836	F_{-2}	22 37 40.39	12 44.83	2.33
.984	.501	F_0	22 50 25.22	12 47.48	2.65
.969	.000	F_2	23 3 12.70	12 50.49	3.01
. . .	. . .	F_4	23 16 3.19	. . . . .	. . .
			. . . . . .		

The following very convenient method of interpolation was published several years ago in an imperfect form in the Mathematical Monthly. The expressions for the constants have been here obtained in a quite different manner, and are given in a different function of the differences, which are more exact, and the whole matter is given in an improved form.

If we put in (1)

$$F_x = F_0 + B_1\, x + B_2\, x^2 + B_3\, x^3, \tag{8.}$$

and determine B_1, B_2, and B_3, so as to make the expression coincide with (1) when $x = \frac{1}{3}$, $x = \frac{2}{3}$, and $x = 1$, we obtain very nearly, reinstating $\Delta^1 - \frac{1}{2}\Delta^2$ for $\Delta_{,}^{1}$, $\Delta^3 - \frac{1}{2}\Delta^4$ for $\Delta_{,}^{3}$, &c.,

$$B_1 = \frac{1}{\omega}\left\{\Delta^1 - \tfrac{1}{2}\Delta^2 - \tfrac{1}{6}\Delta^3 + \left(\tfrac{1}{12} + \tfrac{1}{10}\cdot\tfrac{1}{12}\right)\Delta^4 + \tfrac{1}{33}\Delta^5 - \tfrac{1}{60}\Delta^6 \ldots\right\}$$

$$B_2 = \frac{1}{2\,\omega^2}\left\{\Delta^2 - \left(\tfrac{1}{6} + \tfrac{1}{10}\cdot\tfrac{1}{6}\right)\Delta^4 + \tfrac{1}{30}\Delta^6 \ldots\ldots\right\}$$

$$B_3 = \frac{1}{6\,\omega^3}\left\{\Delta^3 - \tfrac{2}{11}\Delta^5 \ldots\ldots\right\}$$

The greatest possible error, E, in using (8) with these constants instead of (1), is only

$$E = \pm\left(\tfrac{1}{1880}\Delta^4 + \tfrac{1}{1700}\Delta^5 + \tfrac{1}{1400}\Delta^6 \ldots\ldots\right) \tag{9.}$$

If we put

$$(10.)\qquad \delta_x = F_x - F_{(x-1)},$$

we obtain from (8)

$$(11.)\qquad \delta_x = B_1 + (2\,x - 1)\,B_2 + (3\,x^2 - 3\,x + 1)\,B_3,$$

which may be put into the following form: —

$$(12.)\quad \delta_x = A + (\omega + 1 - 2\,x)\,B + (\tfrac{1}{2}\,\omega^2 + \tfrac{3}{2}\,\omega + 1 + 3\,x^2 - 3\,\omega\,x - 3\,x)\,C,$$

in which

$$A = \frac{1}{\omega}\,\Delta^1.$$

$$(13.)\quad B = \frac{1}{2\,\omega^2}\left\{-\Delta^2 - \tfrac{1}{2}\Delta^3 + (\tfrac{1}{6} + \tfrac{1}{10}\cdot\tfrac{1}{6})\Delta^4 + \tfrac{1}{11}\Delta^5 - \tfrac{1}{30}\Delta^6\ldots\ldots\right\}$$

$$C = \frac{1}{6\,\omega^3}\left\{\Delta^3 - \tfrac{2}{11}\,\Delta^5\,\ldots\ldots\right\}$$

By this formula we obtain the first differences, δ_1, δ_2, δ_3, &c., of the interpolated numbers, and from them the numbers themselves. The formula can be used for all values of ω; but when it is taken greater than 12, the numerical coefficients of B and C obtained from (12) for all values of x are not all small enough to be convenient in computation. For all values of ω not greater than 12, by making some slight modifications, we can obtain numerical coefficients convenient in computation. The following are some of the forms most frequently used.

For interpolating to thirds, putting $\omega = 3$, (12) gives,

$$(14.)\qquad \left.\begin{matrix}\delta_1\\ \delta_2\\ \delta_3\end{matrix}\right\} = A \qquad \left.\begin{matrix}+1\\ 0\\ -1\end{matrix}\right\}2\,B \qquad \left.\begin{matrix}+1\\ -2\\ +1\end{matrix}\right\}C.$$

For interpolating to fourths, putting $\omega = 4$, we get

$$(15.)\qquad \left.\begin{matrix}\delta_1\\ \delta_2\\ \delta_3\\ \delta_4\end{matrix}\right\} = A \qquad \left.\begin{matrix}+3\\ +1\\ -1\\ -3\end{matrix}\right\}B \qquad \left.\begin{matrix}+1\\ -1\\ -1\\ +1\end{matrix}\right\}3\,C.$$

For interpolating to fifths, putting $\omega = 5$, we get

$$(16.)\qquad \left.\begin{matrix}\delta_1\\ \delta_2\\ \delta_3\\ \delta_4\\ \delta_5\end{matrix}\right\} = A \qquad \left.\begin{matrix}+2\\ +1\\ 0\\ -1\\ -2\end{matrix}\right\}2\,B \qquad \left.\begin{matrix}+2\\ -1\\ -2\\ -1\\ +2\end{matrix}\right\}3\,C.$$

For interpolating to sixths, putting $\omega = 6$, we get

$$\left.\begin{array}{l}\delta_1\\ \delta_2\\ \delta_3\\ \delta_4\\ \delta_5\\ \delta_6\end{array}\right\} = A \qquad \left.\begin{array}{r}+5\\ +3\\ +1\\ -1\\ -3\\ -5\end{array}\right\} B \qquad \left.\begin{array}{r}+5\\ -1\\ -4\\ -4\\ -1\\ +5\end{array}\right\} 2\,C. \tag{17.}$$

For interpolating to eighths, putting $\omega = 8$, we get

$$\left.\begin{array}{l}\delta_1\\ \delta_2\\ \delta_3\\ \delta_4\\ \delta_5\\ \delta_6\\ \delta_7\\ \delta_8\end{array}\right\} = A \qquad \left.\begin{array}{r}+7\\ +5\\ +3\\ +1\\ -1\\ -3\\ -5\\ -7\end{array}\right\} B \qquad \left.\begin{array}{r}+7\\ +1\\ -3\\ -5\\ -5\\ -3\\ +1\\ +7\end{array}\right\} 3\,C. \tag{18.}$$

For interpolating to tenths, putting $\omega = 10$, we get

$$\left.\begin{array}{l}\delta_1\\ \delta_2\\ \delta_3\\ \delta_4\\ \delta_5\\ \delta_6\\ \delta_7\\ \delta_8\\ \delta_9\\ \delta_{10}\end{array}\right\} = A \qquad \left.\begin{array}{r}+9\\ +7\\ +5\\ +3\\ +1\\ -1\\ -3\\ -5\\ -7\\ -9\end{array}\right\} B \qquad \left.\begin{array}{r}+6\\ +2\\ -1\\ -3\\ -4\\ -4\\ -3\\ -1\\ +2\\ +6\end{array}\right\} 6\,C. \tag{19.}$$

For interpolating to twelfths, putting $\omega = 12$, we get

$$\left.\begin{array}{l}\delta_1\\ \delta_2\\ \delta_3\\ \delta_4\\ \delta_5\\ \delta_6\\ \delta_7\\ \delta_8\\ \delta_9\\ \delta_{10}\\ \delta_{11}\\ \delta_{12}\end{array}\right\} = A + C \qquad \left.\begin{array}{r}+11\\ +9\\ +7\\ +5\\ +3\\ +1\\ -1\\ -3\\ -5\\ -7\\ -9\\ -11\end{array}\right\} B \qquad \left.\begin{array}{r}+9\\ +4\\ 0\\ -3\\ -5\\ -6\\ -6\\ -5\\ -3\\ 0\\ +4\\ +9\end{array}\right\} 6\,C. \tag{20.}$$

In this last form it was necessary to add the small constant C to A in order to obtain small and convenient numerical coefficients of the constant $6\,C$.

The following is an application of the last form to the example of the moon's Right Ascension already given. From (13) we obtain, putting $\omega = 12$,

$A+C$	B	$6\,C$
$+4^{m}\ 13^{s}.8836$	$-0^{s}.1124$	$+0^{s}.0112$
$+4\ 17.4516$	-0.1869	$+0.0136$

With these values of the constants (20) gives the following results: —

			δ^1	δ^2	R. A.
.764	.101	δ_1	$4^{m}\ 12^{s}.749$		$21^{h}\ 59^{m}\ 38^{s}.640$
.988	.045	δ_2	4 12.916	+.167	22 3 51.389
.213	(.0112)	δ_3	4 13.097	.181	22 8 4.305
.438	.966	δ_4	4 13.287	.190	22 12 17.402
.663	.944	δ_5	4 13.491	.204	22 16 30.689
.8876	.933	δ_6	4 13.704	.213	22 20 44.180
.1124	.933	δ_7	4 13.929	.225	22 24 57.884
.337	.944	δ_8	4 14.164	.235	22 29 11.813
.561	.966	δ_9	4 14.411	.247	22 33 25.977
.787	(.9888)	δ_{10}	4 14.670	.259	22 37 40.388
.012	.045	δ_{11}	4 14.941	.271	22 41 55.058
.236	.101	δ_{12}	4 15.221	.280	22 46 9.999
.944	.122	δ_1	.517	.296	22 50 25.220
.318	.054	δ_2	.824	.307	.737
.692	(.0136)	δ_3	.144	.320	.561
.065	.959	δ_4	.475	.332	.705
.439	.932	δ_5	.823	.347	.181
.8131	.918	δ_6	.182	.359	.004
.1869	.918	δ_7	.557	.375	.186
.561	.932	δ_8	.945	.388	.743
.934	.959	δ_9	.345	.400	.688
.308	(.9864)	δ_{10}	.759	.414	.033
.682	.054	δ_{11}	.189	.429	.792
.056	.122	δ_{12}	.630	.442	.980
...	...	..	...	...	.610
					...

In the first column the complements .8876, .8131, &c. of the decimal part of B, since it is negative, are first written down in every twelfth place, and then immediately under, the decimal part itself, after which the multiples are readily filled in. In the second column C is written in one of the blank places of the formula, and its complement in the other, for the convenience of taking the multiples, and placed in parentheses to denote that they are not to be used in the summation of the terms. These two columns then being combined with the decimal part of the constant $A + C$, gives the decimal part of the seconds in δ^1, from which δ^2, or at least the last places of δ^2, are obtained; and by means of it the interior places of δ^1 are readily filled in, when the initial number of δ^1 is known for the first group only. The first differences being thus obtained, the interpolated numbers are readily found. The last group of the preceding example shows the manner in which the computation is carried out at first; after which the remaining part is filled in, as shown in the first group. The computation might be readily carried out by first computing only the last two places of the differences. These have to be computed for one place more than the number of places required in the interpolated results, since small errors in the former might be accumulative in the latter.

In this method of interpolation the regularity of the differences is not a complete check, since a very small error in the value of B might not produce a sensible derangement of the differences. There must, therefore, be a separate check for B, and then the differences furnish a complete check against errors arising from any other source.

Professor Gray made a communication on a new Water Lily, *Nymphæa tuberosa*, of J. A. Paine, from the western part of the State of New York, remarkable for its tuberiferous rootstocks.

Mr. J. I. Bowditch was elected Treasurer, to fill the vacancy made by the decease of Mr. Livermore.

Mr. T. T. Bouvé was elected a member of the Finance Committee, to fill the vacancy left at the annual election.

Mr. Charles J. Sprague was appointed, on the nomination of the President, a member of the Auditing Committee.

DONATIONS TO THE LIBRARY,

FROM MAY 28, 1864, TO MAY 30, 1865.

State of Massachusetts.

Nineteenth Report to the Legislature of Massachusetts relating to the Registry and Return of Births, Marriages, and Deaths in the Commonwealth for the Year ending December 31, 1860. By Oliver Warner, Secretary. 8vo vol. Boston. 1862.

Twentieth Report . . . . for 1861. . . . . 8vo vol. Boston. 1863.

Abstract of the Census of Massachusetts, 1860, from the Eighth United States Census, with Remarks on the Same. 8vo vol. Boston. 1863.

Returns of the Railroad Corporations in Massachusetts, together with Abstracts of the Same, 1860 – 1863. 4 vols. 8vo. Boston. 1861 – 64.

General Statutes of the Commonwealth of Massachusetts: revised by Commissioners. . . . . 8vo vol. Boston. 1860.

Reports of Controverted Elections in the House of Representatives of the Commonwealth of Massachusetts from 1780 to 1852. 8vo vol. Boston. 1853.

Acts and Resolves passed by the General Court of Massachusetts in the Years 1860 – 1864. 5 vols. 8vo. Boston. 1860 – 64.

Journal and Documents of the Valuation Committee of the Year 1860; together with Acts of 1861 to secure a uniform Description and Appraisal of Estates in the Commonwealth. Published by Oliver Warner, Secretary. 8vo vol. Boston. 1861.

Report to the Governor and Council concerning the Indians of the Commonwealth, under the Act of April 6, 1859. By John Milton Earle, Commissioner. 8vo vol. 1861.

Report of the Joint Committee of 1860 upon the proposed Canal to unite Barnstable and Buzzard's Bays. 8vo vol. Boston. 1864.

Statistics of the Condition and Products of Certain Branches of Industry in Massachusetts for the Year ending April 1, 1845. By John G. Palfrey. 8vo vol. Boston. 1846.

Statistical Information relating to Certain Branches of Industry . . . . for the Year ending June 1, 1855. By Francis De Witt. 8vo vol. Boston. 1856.

Annual Report of the Adjutant-General of the Commonwealth of

Massachusetts, with Reports from the Quartermaster-General, etc., for 1861 - 1863. 3 vols. 8vo. Boston. 1862 - 64.

Massachusetts Historical Society.

Collections. Vol. VII. Fourth Series. 8vo. Boston. 1865.

Observatory of Harvard College.

On the Right Ascension of the Pole Star, as determined from Observation. By Truman Henry Safford, Assistant at the Observatory of Harvard College. [From the Proceedings of the American Academy of Arts and Sciences. Vol. VI.] 8vo pamph. Cambridge. 1864.

Museum of Comparative Zoölogy.

Annual Report of the Trustees of the Museum of Comparative Zoölogy at Harvard College, in Cambridge, together with the Report of the Director, 1864. 8vo pamph. Boston. 1865.

Boston Athenæum.

List of Books added to the Library of the Boston Athenæum from December 1, 1863, to December 1, 1864. 8vo pamph. Boston.

Essex Institute.

Proceedings. Vol. III., IV. No. 2 - 4. 8vo. Salem. 1864.

American Antiquarian Society.

Proceedings of the American Antiquarian Society, at the Annual Meeting held in Worcester, October 21, 1864. 8vo pamph. Boston. 1864.

Portland Society of Natural History.

Proceedings. Vol. I. pp. 97 - 128. 8vo. Portland. 1864.

Dartmouth College.

Catalogue of the Officers and Students . . . . for the Academical Year 1864 - 65. 8vo. Hanover, N. H. 1864.

Catalogus Senatus Academici et eorum qui Munera et Officia Academica gesserunt. . . . . 8vo. Hanoveræ, Neo Hant. 1864.

Editors of American Journal of Science and Arts.

Journal. N. S. Vol. XXXVIII., XXXIX. 8vo. New Haven. 1864 - 65.

Lyceum of Natural History of New York.

Annals. Vol. VII. No. 13 - 16. Vol. VIII. No. 1. 8vo. New York. 1862 - 63.

Albany Institute.

Transactions. Vol. IV. 8vo. Albany. 1858 - 64.

Society for the Promotion of Useful Arts in the State of New York.

Transactions. Vol. IV. Part 2. 8vo. Albany. 1819.

Columbia College.

Catalogue of the Officers and Students, for the Year 1864-65. 8vo. New York. 1864.

Academy of Natural Sciences of Philadelphia.

Proceedings. 1864. No. 2, 5. 1865. No. 1. 8vo. Philadelphia. 1864-65.

American Philosophical Society.

Transactions. N. S. Vol. XIII. Part 1. 4to. Philadelphia. 1865.

Proceedings. Vol. IX. No. 71, 72. 8vo. Philadelphia. 1865.

List of the Members of the American Philosophical Society, held at Philadelphia, for promoting Useful Knowledge, formed on the 2d of January, 1769. . . . . 8vo pamph. Philadelphia. 1865.

List of the Surviving Members of the American Philosophical Society, January, 1865, in the Order of their Election to Membership. 8vo pamph. Philadelphia. 1865.

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American Journal of Pharmacy. Ser. 3. Vol. XII., XIII. No. 1, 2. 8vo. Philadelphia. 1864-65.

Smithsonian Institution.

Smithsonian Contributions to Knowledge. Vol. XIII. 4to. City of Washington. 1864.

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Papers relating to Foreign Affairs, accompanying the Annual Message of the President to the First Session of the Thirty-Eighth Congress. Part I., II. 2 vols. 8vo. Washington. 1864.

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Report of the Secretary of the Navy in relation to Armored Vessels. 8vo vol. Washington. 1864.

Mercantile Library Association of the City and County of San Francisco.

Eleventh and Twelfth Annual Report of the Treasurer and Librarian. 2 pamph. 8vo. San Francisco. 1864-65.

Magnetic Observatory, Toronto, C. W.

Abstracts of Magnetical Observations made at the Magnetical Observatory, Toronto, Canada West, during the Years 1856 to 1862

inclusive, and during Parts of the Years 1853, 1854, and 1855. 4to vol. Toronto. 1863.

Abstracts of Meteorological Observations .... during the Years 1854 to 1859 inclusive. 4to vol. Toronto. 1864.

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Philosophical Transactions, for the Year 1863. Vol. CLIII. Part II. For the Year 1864. Vol. CLIV. Part I., II. 4to. London. 1864.

Proceedings. Vol. XIII. No. 60 - 69. 8vo. London. 1864.

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Report of the Astronomer Royal to the Board of Visitors of the Royal Observatory, Greenwich. Read at the Annual Visitation of the Royal Observatory, 1864, June 4. 4to pamph. London. 1864.

Astronomical Observations made at the Royal Observatory, Greenwich, in the Year 1862. 4to vol. London. 1864.

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Results of Meteorological Observations made at the Magnetical Observatory, Toronto, Canada West, during the Years 1860, 1861, and 1862. 4to vol. Toronto. 1864.

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Memoirs. Vol. XXXII. 4to. London. 1864.

Royal Horticultural Society.

Proceedings. Vol. IV., V. No. 1, 2. 8vo. London. 1864 - 65.

British Association for the Advancement of Science.

Report of the Thirty-Third Meeting, held at Newcastle-upon-Tyne, August and September, 1863. 8vo vol. London. 1864.

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Quarterly Journal. Vol. XX., XXI. Part 1. 8vo. London. 1864 - 65.

List of the Society, November 1st, 1862. 8vo pamph.

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Transactions. Vol. XXIV. Part II. 4to. London. 1863.

Journal of the Proceedings. Zoölogy, Vol. VII., VIII. No. 29: Botany, Vol. VII., VIII. No. 29, 30. 8vo. London. 1863-64.

List of the Linnean Society, 1863. 8vo pamph. London.

Address of George Bentham, Esq., F. R. S., etc. The President .... Monday, May 25, 1863: Address .... on Tuesday, May 24, 1864. 2 pamph. 8vo. London. 1863-64.

Zoölogical Society of London.

Transactions. Vol. V. Part III. 4to. London. 1864.

Proceedings for the Year 1863. Part I., II., III. 8vo. London. 1863.

Chemical Society of London.

Journal. Ser. 2. Vol. II., III. No. 25, 26, 27. 8vo. London. 1864-65.

Society of Arts, Manufactures, and Commerce.

Journal of the Society of Arts and of the Institutions in Union. Vol. XII. 8vo. London. 1864.

Royal Society of Edinburgh.

Transactions. Vol. XX.-XXIII. 4to. Edinburgh. 1853-64.

Proceedings. Vol. IV., V. No. 59-64. 8vo. Edinburgh. 1863-64.

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On the Tides of the Arctic Seas. By the Rev. Samuel Haughton, M. A., F. R. S., etc. Part I. On the Diurnal Tides of Port Leopold, North Somerset. 4to pamph. Dublin.

On the Reflection of Polarized Light from Polished Surfaces, Transparent and Metallic. By the Rev. Samuel Haughton..... 4to pamph. Dublin.

Experimental Researches on the Granites of Ireland. Part III. On the Granites of Donegal. By the Rev. Samuel Haughton..... 8vo pamph. London.

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Government of India.

Memoirs of the Geological Survey of India. Vol. III. Part 2: Vol. IV. Part 2. 8vo. Calcutta. 1864.

Palæontologia Indica. Part 3, 2 – 5. 4to. Calcutta. 1864.

Annual Report of the Geological Survey of India and of the Museum of Geology, Calcutta — Eighth Year, 1863 - 64. 8vo pamph. Calcutta. 1864.

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Mémoires. Vol. XXXII. 4to. Paris. 1864.

Mémoires. Morales et Politiques. Vol. XI. 4to. Paris. 1862.

Comptes Rendus. Vol. LVIII., LIX., and LX. No. 1 – 18. 4to. Paris. 1864 – 65.

Société de Géographie.

Bulletin. Sér. 5. Vol. VI., VII. 8vo. Paris. 1863 – 64.

Société Impériale Zoölogique d'Acclimatation.

Bulletin. Sér. 2. Vol. I., II. No. 2, 3. 8vo. Paris. 1864–65.

Société Académique de Maine et Loire.

Mémoires. Vol. XI., XII. 8vo. Angers. 1862.

Académie Impériale des Sciences, etc., Caen.

Mémoires. 8vo vol. Caen. 1864.

Société Linnéene de Normandie.

Mémoires. Vol. XIV., XV. Années 1862 – 63. 1863 – 64. 4to. Caen. 1864 – 65.

Bulletin. Vol. VIII. Année 1862 – 63. 8vo. Caen. 1864.

Société Impériale des Sciences Naturelles de Cherbourg.

Mémoires. Vol. IX., X. 8vo. Paris and Cherbourg. 1863 – 64.

Société de Physique et d'Histoire Naturelle de Genève.

Mémoires. Vol. XVII. Part I. 4to. Geneva. 1863.

Naturforschende Gesellschaft in Bern.

Mittheilungen aus dem Jahre 1863. 8vo. Bern. 1863.

Société des Sciences Naturelles de Neuchatel.

Bulletin. Vol. VI. Cahier 3. 8vo. Neuchatel. 1864.

St. Gallische Naturwissenschaftliche Gesellschaft.

Bericht über die Thätigkeit, 1862 – 63. 8vo vol. St. Gallen. 1863.

Schweizerische Naturforschende Gesellschaft.

Verhandlungen. 47 Versammlung zu Samaden, den 24, 25, und 26 Aug., 1863. 8vo vol. Chur.

Königl. Preussische Akademie der Wissenschaften, Berlin.

Abhandlungen. 1863. 4to. Berlin. 1864.

Monatsberichte. 1863. 8vo. Berlin. 1864.

Universitas Frid. Guil. Rhenana, Bonnæ.

Academical Dissertations and Indexes. Bonn. 1863.

Naturhistorischer Verein der Preuss. Rheinlande und Westphalens.

Verhandlungen. Vol. XX. 8vo. Bonn. 1863.

Naturforschender Verein in Brünn.

Verhandlungen. Vol. I. 1862. 8vo. Brünn. 1863.

Kaiserl. Leopoldinisch-Carolinisch Deutsche Akademie der Naturforscher.

(Academia Cæsarea Leopoldino-Carolina Germanica Naturæ Curiosorum.)

Nova Acta. Vol. XXX., XXXI. 4to. Dresden. 1864.

Naturwissenschaftliche Gesellschaft Isis zu Dresden.

Sitzungs-Berichte. 1863. 8vo. Dresden. 1864.

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Neunundvierzigster Jahresbericht. 1863. 8vo. Emden. 1864.

Kleine Schriften. XI. 4to. Emden. 1864.

Zoologische Gesellschaft, Frankfurt a. M.

Der Zoologische Garten. Vol. V. 8vo. Frankfort-on-the-Main. 1864.

Naturforschende Gesellschaft zu Freiburg im Briesgau.

Berichte über die Verhandlungen. Vol. III. Part 2. 8vo. Freiburg i. Br.

Oberlausitzische Gesellschaft zu Görlitz.

Neues Lausitzisches Magazin. Vol. XLI. 8vo. Görlitz. 1864.

Königl. Gesellschaft der Wissenschaften zu Göttingen.

Abhandlungen. Vol. XI. 4to. Göttingen. 1864.

Nachrichten von der Georg-Augusts-Universität und der Königl. Gesellschaft der Wissenschaften vom Jahre 1863, 1864. 2 vols. 16mo. Göttingen. 1864-65.

Naturforschende Gesellschaft zu Halle.

Abhandlungen. Vol. VII., VIII. 4to. Halle. 1863-64.

Königl. Physikalisch-Ökonomische Gesellschaft zu Königsberg.

Schriften. Vol. IV. 4to. Königsberg. 1863.

Königl. Sächsische Gesellschaft der Wissenschaften, Leipzig.

Abhandlungen. Math.-Phys. Classe. Vol. VI., VII. pp. 1-399. 8vo. Leipsic. 1864.

Berichte über die Verhandlungen. Philol.-Histor. Classe. Vol.

XV., XVI. No. 1. Math.-Phys. Classe. Vol. XV. No. 1, 2. 8vo. Leipsic. 1863 - 64.

Mannheimer Verein für Naturkunde, Mannheim.

Neunundzwanzigster Jahresbericht. 16mo vol. Mannheim. 1863.

Königl. Bayerische Akademie der Wissenschaften, München.

Abhandlungen. Philos.-Philol. Classe. Vol. X. Part 1. 4to. Munich. 1864.

Sitzungsberichte. 1863. Vol. II. Part 2 - 4. 1864. Vol. I. 8vo. Munich. 1863 - 64.

Annalen der Königl. Sternwarte. Vol. XIII. Supplementband, IV. 8vo. Munich. 1863 - 64.

Die Stellung Venedigs in der Weltgeschichte. Rede gehalten von Dr. Geo. Martin Thomas. 4to pamph. Munich. 1864.

Ueber die Stellung und Bedeutung der pathologischen Anatomie. Festrede vorgetragen von Dr. T. Bühl. 4to pamph. Munich. 1863.

Ueber den Begriff der bürgerlichen Gesellschaft. Vortrag gehalten von Dr. W. H. Richl. 4to pamph. Munich. 1864.

König Maximilian II. und die Wissenschaft. Rede gehalten in der Festsitzung der k. Akademie der Wissenschaften zu München am 30 März 1864, von I. v. Döllinger. 8vo pamph. Munich. 1864.

Naturhistorische Gesellschaft zu Nürnberg.

Abhandlungen. Vol. III. Part 1. 8vo. Nürnberg. 1864.

Offenbacher Verein für Naturkunde, Offenbach.

Fünfter Bericht. 8vo vol. Offenbach am Main. 1864.

K. K. Sternwarte zu Prag.

Magnetische und Meteorologische Beobachtungen. Vol. XXIV. 4to. Prague. 1864.

Zoologisch-Mineralogischer Verein in Regensburg.

Correspondenz-Blatt. Vol. XVII. 16mo. Regensburg. 1863.

Abhandlungen. Vol. IX. 8vo. Regensburg. 1864.

Entomologischer Verein zu Stettin.

Entomologische Zeitung. Vol. XXV. 8vo. Stettin. 1864.

Amtlicher Bericht über die acht und dreissigste Versammlung Deutscher Naturforscher und Ärzte in Stettin im Sept. 1863. Herausgegeben von den Geschäftsführern derselben Dr. C. A. Dohrn und Dr. Behm. 4to vol. Stettin. 1864.

Kaiserliche Akademie der Wissenschaften, Wien.

Denkschriften. Math.-Naturw. Classe. Vol. XXII. 4to. Vienna. 1864.

Sitzungsberichte. Math.-Naturw. Classe. Vol. XLVII., XLVIII., XLIX. No. 1. Philos.-Histor. Classe. Vol. XLII., XLIII., XLIV., XLV. No. 1. 8vo. Vienna. 1863 - 64.

Anzeiger. Math.-Naturw. Classe. Vol. I., II. No. 1 - 20. 8vo. Vienna. 1864 - 65.

K. K. Geographische Gesellschaft, Wien.

Mittheilungen. Vol. VI. Roy. 8vo. Vienna. 1862.

K. K. Geologische Reichsanstalt, Wien.

Jahrbuch. Vol. XIII., XIV. No. 3, 4. 8vo. Vienna. 1863.

Die Fossilen Mollusken des Tertiær-Beckens von Wien, von Dr. Moritz Hörnes. Vol. II. No. 5, 6. Bivalven. 4to. Vienna. 1865.

K. K. Zoologisch-Botanische Gesellschaft, Wien.

Verhandlungen. Vol. XIII. 8vo. Vienna. 1863.

Monographie der Oestriden von Friedrich Brauer. 8vo vol. Vienna. 1863.

Académie Royale des Sciences, &c., de Belgique, de Bruxelles.

Mémoires. Vol. XXVIII., XXXIV. 4to. Brussels. 1854 - 64.

Mémoires Couronnés, &c. Vol. XXII., XXVI., XXXI. 4to. Brussels. 1848, 1855, 1863.

Mémoires Couronnés. Col. in 8vo. Vol. XV., XVI. 8vo. Brussels. 1863 - 64.

Bulletin. Sér. 2. Vol. XV - XVII. 8vo. Brussels. 1863 - 64.

Annuaire. Vol. XXX. 18mo. Brussels. 1863 - 64.

Observatoire Royale de Bruxelles.

Annales. Vol. XVI. 4to. Brussels. 1864.

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Académie Royale des Sciences à Amsterdam.

Verhandelingen, Afdeeling Letterkunde. Vol. II. 4to. Amsterdam. 1863.

Verslagen en Mededeelingen. Afd. Letterkunde. Vol. VII. Afd. Natuurkunde. Vol. XV., XVI. 8vo, Amsterdam. 1863 - 64.

Jaarboek voor 1862. 8vo. Amsterdam.

De Lebetis Materie et Forma ejusque Tutela in Machinis Vaporis Vi agentibus. Carmen Didascalicum, cujus Auctori Josepho Giacoletti Pedemontano, Certaminis Poetici Praemium adjudicatum est..... IX Martii, 1863. 8vo. Amsterdam. 1863.

Netherlands Government.

Flora Batava, of Afbeeldingen Beschrijving van Nederlandsche Gewassen. Aflevering 184, 187 - 189. 4to. Amsterdam.

Carte Geologique des Pays-Bas. No. 3, 4, 8, 11, 12, 15 – 20. 11 Charts. Haarlem.

Hollandsche Maatschappij der Wettenschappen te Haarlem.

Natuurkundige Verhandelingen. Serie 2. Vol. XVIII., XIX., XXI. Part 1. 4to. Haarlem. 1863 – 64.

Koninklijk Nederlandsch Meteorologisch Instituut.

Meteorologische Waarnemingen in Nederland en Zigne Bezittingen. . . . . Long 4to vol. Utrecht. 1864.

Observatoire d' Utrecht.

Recherches Astronomiques de l'Observatoire d'Utrecht, publiées par M. Hoek, Dir. de l'Obs. Livr. II. 4to. The Hague. 1864.

Recherches sur la Quantité d'Ether contenue dans les Liquides, par M. Hoek et A. C. Oudemans. . . . . Addition à la Prémière Livraison des Recherches Astron. de l'Obs. d'Utrecht. 4to. The Hague. 1864.

Académie Impériale des Sciences de St. Petersbourg.

Mémoires. Sér. 7. Vol. V. No. 2 – 9. Vol. VI. 4to. St. Petersburg. 1862 – 63.

Bulletin. Vol. V. No. 3 – 8: Vol. VI. No. 1 – 5: Vol. VII. No. 1 – 2. 4to. St. Petersburg. 1863.

Administration of Mines of Russia.

Annales de l'Observatoire Physique Central de Russie. 1860, No. 1, 2: 1861, No. 1, 2. 4to. St. Petersburg. 1863 – 64.

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Bulletin. 1863. No. 3, 4: 1864. No. 1. 8vo. Moscow. 1863 – 64.

Naturforschender Verein zu Riga.

Correspondenzblatt. Vol. XIV. 8vo. Riga. 1864.

Kongel. Danske Videnskabernes Selskab, Kjöbenhavn.

Oversigt. Forhandlinger. 1862 – 1863. 8vo. Copenhagen. 1862 – 63.

Royal Society of Northern Antiquaries, Copenhagen.

Notices of the Life and Writings of Carl Christian Rafn, Permanent Secretary of the Royal Society of Northern Antiquaries. By Laurent Etienne Borring. 8vo pamph. Copenhagen. 1864.

Kongel. Norske Frederiks Universitet, Christiania.

Aarsberetning for 1862. 16mo pamph. Christiania. 1863.

Forhandlinger i Videnskabs-Selskabet i Christiania. 1858 – 63. 8vo. Christiania. 1859 – 64.

Index Scholarum. 1863. 2 pamph. 4to. Christiania. 1864.

Nyt Magazin for Naturvidenskaberne. Udgives af den physiographiske Forening i Christiania ved M. Sars og Th. Kjerulf. Vol. XIII. Part 1-3. 8vo. Christiania. 1863-64.

Om Snebræen Folgefon af S. A. Sexe. Udgivet som Universitetsprogram for an det Halvaar 1864. 4to pamph. Christiania. 1864.

Aegyptische Chronologie. Ein kritischer Versuch von J. Lieblein. .... Herausgegeben von der Gesellschaft der Wissenschaften zu Christiania. 8vo vol. Christiania. 1863.

Oversigt af Norges Echinodermer ved Dr. Michael Sars. Udgiven af Videnskabsselskabet i Christiania. 8vo vol. Christiania. 1861.

Resultate Magnetischer, Astronomischer und Meteorologischer Beobachtungen auf einer Reise nach dem Östlichen Sibirien in den Jahren 1828-1830 von Christoph Hansteen und Lieutenant Due. 4to pamph. Christiania. 1863.

Om de Geologiske Forhold paa Kyststrækningen af Nordre Bergenhaus Amt. af M. Irgens og Th. Hiortdal. Efter det academiske Collegiums Foranstaltning udgivet som Universitetsprogram for andet Halvaar 1864 ved Dr. Th. Kjerulf. 4to pamph. Christiania. 1864.

Kongl. Svenska Vetenskaps Akademien.

Ofversigt af Kongl. Vetenskaps Akademien Forhandlinger. Vol. XX. 8vo. Stockholm. 1863.

Meteorologiska Iakttagelser i Sverige utgivne af Kong. Svenska Vetenskaps-Akademien af Er. Edlund. Vol. IV. 1862. 8vo. Stockholm. 1864.

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Resumen de las Actas .... en el Año Academico de 1861-1862. 12mo. Madrid. 1863.

Libros del Saber de Astronomia del Rey D. Alfonso X de Castilla, copilados, antados y comentados, por Don Manuel Rico y Sinobas. 2 vols. folio. Madrid. 1863.

Observatorio de Marina de San Fernando, Cadiz.

Almanaque Nautico para el Año 1866. 8vo. Cadiz. 1864.

Accademia della Scienze dell' Istituto de Bologna.

Memorie. Vol. X., XI., XII. Serie 2. Vol. I., II. 4to. Bologna. 1859, 1861, 1862.

Rendiconto delle Sessioni dell' Accademia — Anno Accademico 1860 - 61, 1861 - 62, 1862 - 63. 8vo. Bologna. 1861 - 63.

Societa Reale di Napoli.

Atti dell' Accademia delle Scienze, Fisiche e Matematiche. Vol. I. 4to. Naples. 1863.

Rendiconto. Vol. II. Part 8 - 12: Vol. III. Part 1, 2. 4to. Naples. 1863 - 64.

Reale Istituto d' Incorriaggiamento di Agricoltura, Arti e Manufatture in Sicilia.

Ser. 3. Vol. I. No. 1 - 6. 8vo. Palermo. 1863.

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Five hundred and fifty-sixth Meeting.

October 10, 1865. — ADJOURNED STATUTE MEETING.

The PRESIDENT in the chair.

The President called the attention of the Academy to the recent decease of Dr. Francis Wayland of Providence, of the Associate Fellows; also among the Foreign Honorary Members, of Sir John William Lubbock, Sir William Rowan Hamilton, the astronomer Encke, Admiral William H. Smyth, and Admiral Lois Isidore Duperrey.

Mr. John C. Lee was elected Treasurer of the Academy to fill the vacancy left by the declination of Mr. Bowditch, who was elected at the previous meeting.

Mr. Ferrel presented the following paper: —

On an Annual Variation in the Daily Mean Level of the Ocean, and its Cause.

IN discussing a large number of tidal observations, made at Brest, one of the results obtained is an annual variation of the mean level of the ocean which cannot be explained by the hitherto recognized changes of mean level. The mean height obtained for each month of the year is given in the following table, in which each monthly mean

is the result of about 800 observations of high water and as many of low water. The only causes which have been supposed to affect the mean level are a small astronomical term depending upon the sun's declination, the variation of atmospheric pressure, and the winds. The effect of the astronomical term is equal to $a \cos 2l$, in which a is a function of the latitude of the port, and l is the sun's longitude. The effect of the variation of atmospheric pressure is equal to $13^m.568\ (P - p)$, in which p is the observed barometric pressure of the atmosphere in meters, and P the annual mean pressure. The coefficient $13^m.568$ is assumed upon the hypothesis that the variation of the mean level of the ocean at any place is to the variation of the barometric column as the specific gravity of mercury is to that of water. M. Dausy obtained $15^m.5$ for this coefficient from 150 observations of the tides and of atmospheric pressure, made at Lorient, but Mr. Lubbock from observations at Liverpool obtained only 11.1 for that port. The theoretical value is perhaps more nearly correct than either of the other two. In the second numerical column of the following table is given the atmospheric pressure at Paris in millimetres for each month of the year, taken from Kaemtz's Meteorology, which is assumed to vary but little from the pressure at Brest, so that it may be used in computing the effect of the variation of pressure upon the mean level of the sea at that port. The following variations of mean level corrected for the astronomical term and variation of atmospheric pressure must be the effect of the winds, and other causes. The value of a in the astronomical term for the latitude of Brest is — .007. The corrections and the corrected monthly mean heigths of the ocean are also given in the following table.

Month.	Monthly Mean Heights.	Atmospheric Pressure.	Astronomical Correction.	Atmospheric Correction.	Corrected Mean Heights.
	m. 4.437	mm. 756.46			4.437
January	+ 0.020	+ 2.40	— 0.005	+ 0.032	+ 0.047
February	— 0.016	+ 2.63	+ 0.003	+ 0.035	+ 0.022
March	— 0.054	— 0.13	+ 0.007	— 0.002	— 0.049
April	— 0.033	— 1.28	+ 0.005	— 0.017	— 0.045
May	— 0.019	— 0.85	— 0.003	— 0.011	— 0.033
June	— 0.061	+ 0.82	— 0.007	+ 0.011	— 0.057
July	— 0.043	+ 0.06	— 0.005	+ 0.001	— 0.047
August	— 0.030	+ 0.28	+ 0.003	+ 0.004	— 0.023
September	— 0.005	+ 0.15	+ 0.007	+ 0.002	+ 0.004
October	+ 0.076	— 2.04	+ 0.005	— 0.027	+ 0.054
November	+ 0.071	— 0.70	— 0.003	— 0.010	+ 0.058
December	+ 0.073	— 1.37	— 0.007	— 0.018	+ 0.068

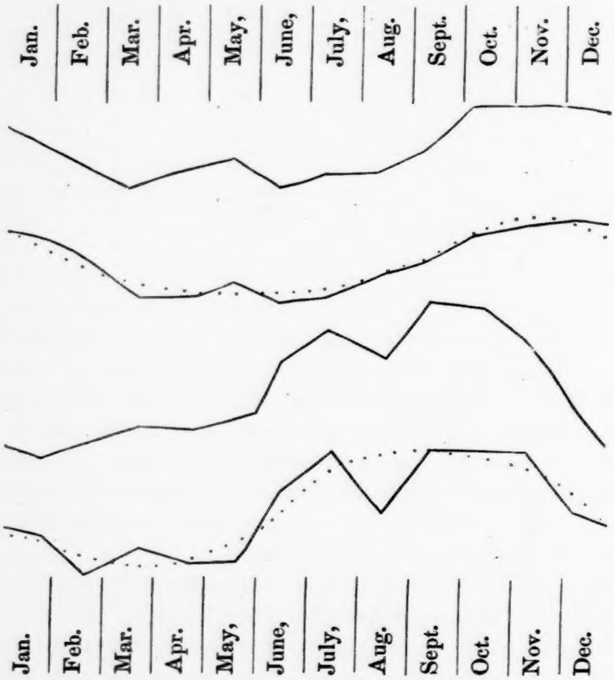
In connection with these results are given in the following table those obtained by Dr. Bache from the discussion of the tides at Key West, Florida, and published in the Coast Survey Reports, and also in Silliman's Journal (Second Series, Vol. XVIII. p. 305). They have been reduced from English feet to meters for convenience of comparison with the preceding results. The second numerical column contains the variations of atmospheric pressure at Havana, which is used for computing the corrections at Key West due to that cause. The coefficient of the astronomical term for Key West is + .005. The corrections and the corrected results are also given in the following table: —

Month.	Monthly Mean Heights.	Atmospheric Pressure.	Astronomical Correction.	Atmospheric Correction.	Corrected Mean Heights.
	m. 1.677	mm. 760.27			mm. 1.677
January	− 0.118	+ 4.97	+ 0.003	+ 0.066	− 0.049
February	− 0.100	− 0.12	− 0.002	− 0.002	− 0.104
March	− 0.073	+ 0.71	− 0.005	+ 0.009	− 0.069
April	− 0.073	− 0.69	− 0.003	− 0.009	− 0.085
May	− 0.055	− 2.08	+ 0.002	− 0.028	− 0.081
June	+ 0.031	+ 0.40	+ 0.005	+ 0.005	+ 0.041
July	+ 0.085	+ 0.40	+ 0.003	+ 0.005	+ 0.093
August	+ 0.040	− 2.94	− 0.002	− 0.039	− 0.001
September	+ 0.130	− 2.81	− 0.005	− 0.037	+ 0.088
October	+ 0.121	− 2.08	− 0.003	− 0.028	+ 0.090
November	+ 0.070	+ 0.98	+ 0.002	+ 0.013	+ 0.085
December	− 0.058	+ 3.35	+ 0.003	+ 0.045	− 0.008

For the convenience of comparison the following graphic representation of the results for the two ports is given, the first and third curves representing the annual variation of mean level at Brest and Key West respectively, uncorrected for the effects of the astronomical term and the variation of atmospheric pressure, and the second and fourth the corrected results. The curves are somewhat irregular, because the number of both tidal and barometric observations is not great enough to eliminate all the accidental and other irregularities; but the dotted curves, cutting off small irregularities, although somewhat arbitrary, must very nearly represent the true results.

With regard to the effect of the winds in changing the mean level of the sea, either at Brest or Key West, little is known, but it is evident from various researches at other ports, that they can have but little effect, except for very short periods during heavy gales, and therefore cannot cause much change in the monthly means, or the means of the different seasons. M. Dausy concluded from his researches that the mean level of the sea was not sensibly altered at Lorient by breezes

or fresh winds, but that it fell $0^{m}.080$ by violent winds from the north to northeast, and rose the same quantity by those from the southwest, the south, or the southeast. (*Comptes Rendus de l'Académie des Sciences*, Tom. III. p. 136.) We have, therefore, reason to suppose that the variations in the prevailing winds in the different seasons of the year, since their averages or resultants cannot amount to more than a very gentle wind, can have but a small effect upon the mean level at Brest. Moreover, the winds from the south and southwest, which tend to cause a rise in the mean level, prevail the most, and with the greatest force, during the winter and spring, and hence cannot cause the preceding corrected variation of mean level, which is at its minimum during that time. There must, therefore, be yet some other cause affecting the mean level of the sea at Brest.



With regard to the effect of the winds on the mean level of the sea at Key West, Dr. Bache remarks, that "winds tending to elevate the water in the harbor prevail for six months, from March to August

inclusive, and those tending to depress it, for the other six months, from September to February inclusive." By referring to the preceding curve representing the variation of mean level at Key West, it is seen that these winds cannot cause the corrected variation of mean level, since the argument of variation of the former does not at all correspond with that of the latter, and hence there must be still some other cause affecting the mean level of the sea at Key West also.

From what has been stated, it is evident that the effect of the winds at Brest must be to decrease the amount of variation, and to cause the maximum and minimum to happen a little later in the season of the year. On the other hand, their effect at Key West must increase the variation and cause the maximum and minimum to happen earlier in the season of the year. If, therefore, the variations of mean level at Brest and Key West were corrected for the effect of the winds, the arguments of the variations at both ports would probably be the same, making the maxima and minima of the variations about October and April. This indicates that the cause or causes of the variation of mean level which we have yet to seek are not local, but more general, affecting both ports simultaneously. There have been no researches to show that the argument of the corrected variation of mean level would be about the same at other ports of the Atlantic ocean also.

There is still another cause affecting the mean level of the ocean at different seasons, which is much more effective than either of those which have been stated, and which, I think, satisfactorily accounts for the remaining and greater part of the observed variation, which has not been explained. This is a tangential force arising from the motions of the ocean combined with the motion of the earth's rotation. It was first brought out in its most general form in my paper on the "Motions of Fluids and Solids relative to the Earth's Surface," published in the Mathematical Monthly, and also in an abridged form in Silliman's Journal (Second Series, Vol. XXXI.), and expressed in the following language: *In whatever direction a body moves on the surface of the earth, there is a force arising from the earth's rotation which deflects it to the right in the northern hemisphere, but to the left in the southern hemisphere.* From this force there must arise a change in the level of the sea wherever its waters have a motion of any kind, and as these motions depend, for the most part, upon the difference of temperature of the ocean between the equator and the poles, and consequently upon the change of seasons, there must be a change in the mean level of the

sea at most ports corresponding with the change of seasons. The principal motion of the water of the Atlantic Ocean affecting its level is the motion by which it is supposed to complete a gyration in about three years. In the paper already referred to it was shown that the force arising from this gyration would cause the middle of the gyrating mass of the water to stand about five feet higher than the exterior part on the coast of Europe and America. Now as the greatest difference of temperature in the ocean between the equator and the poles must be in the latter part of winter, a little later than the time of the greatest difference in the atmosphere between the equator and the poles, the greatest gyratory motion of the water of the Atlantic Ocean, on account of the inertia of the water, must happen still a little later, say in April, and then the surface of the water must stand highest in the centre of the gyrating part, and lowest at the exterior part, and consequently at the ports of Brest and Key West. On the contrary, in October, when the gyratory motion is the least, the surface must fall a little in the middle and rise a little at its exterior part, and consequently stand at its maximum height at the ports of Brest and Key West. The position of the gyrating mass also changes with the seasons, being farthest north in the fall, and nearest the equator in the spring, as must necessarily be the case, and as the vibrating motion of the northern part of the Gulf Stream indicates. The surface of the gyrating water being a little convex, this circumstance must also affect the mean level slightly at some ports.

The difference between the maximum and minimum mean height of the sea at Brest is about six inches, which, when corrected for the effect of the winds and other causes, would probably be a little more. The difference at Key West, corrected in like manner, would probably be about the same. A decrease, therefore, of less than one half in the gyratory velocity of the ocean from April to October would be sufficient to cause a variation of that amount in the mean level of the sea at Brest and Key West; and as the argument of the variation of the gyratory motion of the Atlantic Ocean, as we have seen, must very nearly or quite correspond with the argument of the variation of mean level unaccounted for by other causes, we have reason to think that the variation of the gyratory motion of the Atlantic Ocean is the cause of this part of the change of mean level.

Five hundred and fifty-seventh Meeting.

November 8, 1865. — STATUTE MEETING.

The PRESIDENT in the chair.

Mr. Safford presented the following paper: —

On the Right-Ascensions observed at Harvard College Observatory in the Years 1862 – 1865. By T. H. SAFFORD.

IT is part of every astronomer's duty to assure himself in some way of the accuracy of the elements upon which the reduction of his observations depend. If he is a meridian observer, he must make sure that the right-ascensions of the clock- and polar-stars which he employs are correct; and the most thorough means of so doing is to determine them by his own observations.

It is true that this process requires much time and patience; that we, in America, are tempted to think that it has all been so excellently done abroad, that anything we can do will not add to the accuracy of the determinations we derive from foreign sources. I think this notion is somewhat ill-founded. The quantities in question are, as above stated, the right-ascensions of standard stars; they must be predicted, and are so predicted for many years in advance; and the simple formula by which this prediction has to be made,

$$a' = a + \frac{a - a^0}{t - t^0}(t' - t) + \Delta p \frac{(t' - t^0)}{2}\frac{(t - t^0)}{}$$

$$= a \frac{t' - t^0}{t - t^0} - a^0 \frac{t' - t}{t - t^0} + \Delta p \frac{(t' - t^0)\ (t - t^0)}{2},$$

shows that not only do the errors of the modern observations come in with more than their full amount, but are somewhat increased by a part of those of the ancient ones.

It ought also to be considered that the observations made with any meridian instrument are liable to errors of obscure origin, which make it somewhat better to use its own results to reduce other observations obtained with it; and that, on the other hand, each good instrument well used, and each well-trained observer, contributes something to the general foundations of the science which no other observer or instrument can do.

The eminent German, English, Russian, and French astronomers have followed this plan within the present century.

Admirable fundamental catalogues have appeared from the observatories of Königsberg, Åbo, Dorpat, Cambridge (Eng.), Greenwich, Edinburgh, and Paris; and two from Pulkova and one from Leiden are to appear within a few years.

I wish to call the attention of American observers to this subject, and will give a short sketch of the process, and enumerate the systematic errors which must be guarded against, and their sources.

First, it is assumed that an approximate catalogue of time-stars is at hand; the first object is to obtain a correct right-ascension of Polaris, peculiar it may be in some degree to observer and instrument, and this is done by opposite culminations, at all seasons; or at two opposite seasons, as spring and autumn. If the values for spring and for autumn differ by any sensible amount, the instrument is ill-mounted, but a constant difference of three seconds of time here did not prevent Bessel from obtaining a value accurate to $0^s.3$. In our Cambridge observations of Polaris, this difference has been much less; in fact hardly sensible.

The next step is to derive the right-ascensions of other polar stars from that of Polaris; and it is here necessary to observe at two opposite seasons of the year, or, which is the same thing, at two opposite culminations.

Now comes the comparison of time stars among themselves, and the best method, and the method which must in all cases form the ultimate test, is to begin by comparing at two opposite seasons the stars Castor, Procyon, and Pollux with the stars γ, α, β Aquilæ; and, finally, to compare the remaining fundamental stars (Maskelyne's 36, for example) with both these groups, though oftener with the nearest one. But this is a method which requires a very perfect clock, especially with perfect compensation, or else not exposed to changes of temperature. In case it is not practicable, we may content ourselves for a time with the more ordinary process of assuming the freedom from constant error of large groups of stars, and thus getting the individual errors of the assumed fundamental catalogue; and the only objection which I know to it is, that being almost universally employed, and Bessel's Fundamenta being the old Catalogue always used for proper motion, we may in this way accumulate dangerous errors, sensibly identical, in nearly all modern observations. It is, therefore, desirable that this point, too, should be tested oftener than it is.

At the Observatory of Harvard College, a fundamental catalogue

of about three hundred and twenty stars is now in process of reduction, which depends on nearly ten thousand observations made since 1862. The instrument has shown a stability of mounting sufficient for an independent and accurate determination of thirty-five polar stars, while it has also proved itself capable of being used for exact right-ascensions of time-stars by the excellence of its pivots, and its general stiffness.

The catalogue will be, if I am not mistaken, the first American Fundamental Catalogue of Right-Ascensions; I can venture to call it so, although the still unfinished normal clock, and the lack of a good circle for solar observations, compel some reliance upon the general accuracy of other determinations. But with the requisite apparatus, about one thousand more observations would free us from even this necessity.

Mr. Oliver presented the following paper: —

On some Focal Properties of Quadrics. By J. E. OLIVER.

I. Any two quadrics have one, and usually but one, common autopolar tetrahedron, **T**. Referred to this their equations become

$$U = a w^2 + b x^2 + c y^2 + d z^2 = 0,$$
$$\Upsilon = \alpha w^2 + \beta x^2 + \gamma y^2 + \delta z^2 = 0,$$

whether in tangential or in point-coördinates. Using tangential coördinates, all the quadrics

$$U + \lambda \Upsilon = (a + \lambda \alpha) \omega^2 + \ldots\ldots = 0 \qquad (1)$$

have a common enveloping developable; and the entire system is determined by any two of its quadrics [or by any eight of its developable's planes which are not specially related].

The four quadrics that correspond to

$$\lambda = -\frac{a}{\alpha},\ \lambda = -\frac{b}{\beta},\ \lambda = -\frac{c}{\gamma},\ \text{and } \lambda = -\frac{d}{\delta},$$

are *plane conics* in the respective planes of reference.

Deforming **T** and (1) together till **T** has one plane at infinity and the other three mutually orthogonal, and then lengthening in suitable proportions the three sets of principal axes, the rectangular point-equation of the system becomes

$$\frac{x^2}{A^2 + k^2} + \frac{y^2}{B^2 + k^2} + \frac{z^2}{C^2 + k^2} = 1, \qquad (2)$$

which is a homofocal system. Three of the plane curves in (1) have become the focal conics in (2). And the fourth curve in (1) becomes in (2) the ***spherical circle at infinity***, i. e. the intersection of any finite and finitely-distant sphere, with the plane at infinity, **P**.

For since the cone,

$$x^2 + y^2 + z^2 = 0, \tag{3}$$

which envelops that circle, is sensibly asymptotic to the surfaces (2) when k is indefinitely large, the common tangent-planes to those surfaces then differ not sensibly from the cone's tangent-planes, and hence envelop the circle.

Hence, as Salmon shows, a quadric's three focal curves, with the spherical curve at infinity, are the intersections of non-consecutive rays of that developable which envelops both it and the spherical curve. And they are the *only* intersections; for, being of the fourth degree, the developable cannot cross one of its own rays more than four times.

Any deformation that destroys a sphere, destroys with it the circle at infinity and the homofocalism of system (2), unless it replace that circle by one of (2)'s focal conics; hence the system has but four projective forms. And since, as its tangential equation shows, any four of its quadrics divide each ray of the developable in the anharmonic ratio of their k^2s, this ratio must remain after deformation; hence in the respective forms, k^2 is, at the respective plane curves,

$$\begin{aligned} = -A^2,\ -B^2,\ -C^2,\ \infty^2, \\ -B^2,\ -A^2,\ \infty^2,\ -C^2, \\ -C^2,\ \infty^2,\ -A^2,\ -B^2, \\ \infty^2,\ -C^2,\ -B^2,\ -A^2; \end{aligned}$$

hence the four plane conics *exactly replace* one another; and so do their four included groups of quadrics, since projection breaks no cyclic order.

II. The system (2) touches every point of space three times, every line twice, every plane once; except that it meets each ray of the developable *throughout*. A line's two planes of contact with the system are known to be mutually perpendicular, so that the boundaries of two homofocals are seen from any point to intersect at right angles if at all. For if the line touch

$$\frac{x_1^2}{A^2 + k_1^2} + \dots\dots = 1, \qquad \frac{x_2^2}{A^2 + k_2^2} + \dots\dots = 1,$$

at $(x_1\, y_1\, z_1)$ and $(x_2\, y_2\, z_2)$ respectively, either point is on the other's polar as to each quadric; or,

$$\frac{x_1\, x_2}{A^2 + k_1^2} + \ldots\ldots = 1, \qquad \frac{x_1\, x_2}{A^2 + k_2^2} + \ldots\ldots = 1,$$

whose difference,

$$\frac{x_1\, x_2}{(A^2 + k_1^2)\,(A^2 + k_2^2)} + \ldots\ldots + \frac{z_1\, z_2}{(C^2 + k_1^2)\,(C^2 + k_2^2)} = 0, \qquad (4)$$

is the condition that the two tangent-planes are perpendicular.

Or thus. The pairs of tangent-planes drawn from the line $(x_1\, y_1\, z_1)$, $(x_2\, y_2\, z_2)$, to the different surfaces, are known to form an involution, whose double planes, namely the tangents at $(x_1\, y_1\, z_1)$ and $(x_2\, y_2\, z_2)$, must form a harmonic pencil with the tangent-planes to any one surface, e. g. to the spherical circle at infinity, and hence are orthotomic.

Particular cases of this orthotomism are that of the three quadrics through one point, and the circularity of the cone mentioned in § IV.

Now this orthotomism would preclude the existence of a common developable; but it fails for the envelope's rays; for since every tangent-plane from a finitely-near point to the circle at infinity has some infinite direction-cosines, while

$$D_{N_1}\ U_1 \cdot D_{N_2}\ U_2 \cdot \cos a_1 \cdot \cos a_2 = \frac{x_1\, x_2}{(A^2 + k_1^2)\,(A^2 + k_2^2)}, \text{ \&c.,}$$

are finite, [U_1, U_2, N_1, N_2, a_1, ... γ_2, being the quadrics, their normals, and the direction-angles of these,] — it must be that

$$D_{N_1}\ U_1 \cdot D_{N_2}\ U_2 = 0\,;$$

hence (4), which is the same as

$$D_{N_1}\ U_1 \cdot D_{N_2}\ U_2 \cdot (\cos a_1 \cos a_2 + \cos \beta_1 \cos \beta_2 + \cos \gamma_1 \cos \gamma_2) = 0,$$

becomes merely identical. And the other demonstration fails, because the two tangent-planes to the circle at infinity coincide.

III. According to Salmon, each ray to a spherical point at infinity is "*perpendicular to itself*" (whatever that may mean); which would extend the above orthotomism to the developable; a result opposite to ours in statement, but probably the same in its actual consequences. Such lines must often thus simulate self-perpendicularity, from their infinite direction-cosines having zero co-factors; and this may make

Salmon's interpretation often convenient and suggestive, though I think it is arbitrary.

If a finitely-near plane [or line] should make an angle θ with itself, it would doubtless touch [or meet] a sphere's circle at infinity; for we should have

$$\cos^2 a + \cos^2 \beta + \cos^2 \gamma = \cos \theta,$$

while

$$\cos^2 a + \cos^2 \beta + \cos^2 \gamma = 1,$$

$$\therefore 0 \cdot \cos^2 a + 0 \cdot \cos^2 \beta + 0 \cdot \cos^2 \gamma = 1 - \cos \theta,$$

$$\therefore \text{some of } (\cos a, \cos \beta, \cos \gamma) = \infty,$$

which is the condition of such contact; [nor need θ nor ∞ be real.] But the converse fails; for

$$\cos a = \infty$$

does not imply

$$\cos^2 a + \cos^2 \beta + \cos^2 \gamma \mp 1.$$

Nor, if θ *can* be > 0, need it be always $90°$. Various considerations often suggest $90°$, as in Salmon's beautiful instance of a circle's tangent-radius. But should not the common tangent of circles

$$\left.\begin{aligned} x^2 + y^2 &= 1, \\ x^2 + y^2 &= 4, \end{aligned}\right\} \text{ found thus, } \left\{\begin{aligned} x \cos a + y \sin a &= 1, \\ x \cos a + y \sin a &= 2, \\ \therefore \cos a &= \infty, \end{aligned}\right.$$

make in like manner such angles with itself as the circles make with each other's ordinary tangents, namely,

$$60°, \quad \text{and } (\log \overline{2 + \sqrt{3}}) \cdot \sqrt{-1} \quad ?$$

Of course in either instance, to throw the self-contradiction, instead, upon the circle's angle ϵ with its radius vector, we need only regard it as the limiting case of another curve or of an eccentric circle, so that ϵ may be a function of the independent polar angle ϕ.

IV. If quadrics U, V, W, expressed in tangential coördinates, have a common developable envelope, so have $U + \lambda \Upsilon$, $V + \mu \Upsilon$, W; μ being a linear function of λ; for the equation

$$l\,U + m\,V + W = 0,$$

implies

$$l\,(U + \lambda \Upsilon) + m \left(V - \frac{l \lambda}{m} \Upsilon\right) + W = 0.$$

If now Υ be the spherical circle at infinity, and W two separate or coincident points, we see that *when U has double contact with V, or envelopes it, so does every homofocal to U some homofocal to V;* and all the planes of contact intersect in one line or point.

U may have 2, 3, or 4 double contacts with the surfaces $V + \mu\Upsilon$, since the condition

$$l \cdot U + m \cdot V + m\mu \cdot \Upsilon = \text{product}$$

is equivalent to three quadric conditions among $(l, m, m\mu)$, which are satisfied in from 0 to 4 ways, just as three conics have from 0 to 4 common intersections. 1 of these double contacts may be replaced by 1 envelopment; or all 4 by 2 envelopments if (U, V) be cones. *If* U *have* p *double contacts and* q *envelope-contacts with surfaces* $\mathrm{V} + \mu\Upsilon$, *so has* V *with surfaces* $\mathrm{U} + \lambda\Upsilon$.

Of the fact that homofocals envelop homofocals, a familiar case is that each focal line of a cone U touches either co-planar focal of any enveloped quadric V; whence the circularity of that enveloping cone whose vertex is on a focal; and the consequent linear relation among the four distances of two points on one focal from two on the other, &c. Other known cases are, that U's focal lines, when not thus co-planar, are generators of some homofocal to V; and that when U is a quadric of revolution, its foci lie upon V's focals. For in neither of these three cases could the focal curve of U otherwise envelop any homofocal of V.

P. S. Feb. 10, 1866. — The above was in the printer's hands, before I was aware how much of it had been given by Salmon; but I retain it with some changes, as certain points in it may still be new. — J. E. O.

The following gentlemen were elected members of the Academy, viz.: —

J. Victor Poncelet, of Paris, was elected a Foreign Honorary Member, in Class I., Section 4, in place of the late M. Struve.

Mr. Lewis M. Rutherfurd, of New York, was elected Associate Fellow, in Class I., Section 3.

Mr. Samuel Eliot, of Boston, was elected a Resident Fellow, in Class III., Section 3, and Mr. G. W. Hill, of Cambridge, a Resident Fellow, in Class I., Section 2.

Five hundred and fifty-eighth Meeting.

November 14, 1865. — MONTHLY MEETING.

The PRESIDENT in the chair.

The President called the attention of the Academy to the recent decease of the eminent lexicographer Dr. Joseph E. Worcester, of the Resident Fellows.

Professor Lovering, from the Rumford Committee, delivered to the President the Rumford Medal, which had been prepared in accordance with a vote of the Academy to be presented to Professor Treadwell.

The President prefaced the presentation of this medal with the following remarks: —

At the Anniversary Meeting last May, upon the unanimous recommendation of our Rumford Committee, the medal founded by Count Rumford was by the Academy awarded to Professor Daniel Treadwell for certain improvements in the management of heat. This medal is now before us. It is the first which the Academy has ever bestowed upon one of its immediate members.

As your organ upon this occasion, before we place this testimonial in the hands of our distinguished associate, it is proper that I should briefly specify the grounds upon which your Committee proposed, and you made, this award. It is well understood, and the terms of the vote distinctly show, that this medal was awarded for an invention or an improvement in the management of heat. It is also well known that this particular improvement is a part — the initial part, indeed — of a series of inventions, — applicable to other uses, no doubt, — but through which the character of ordnance has been changed, and its power immensely increased. This was the end and aim of the improvement for which the medal is given.

We may, therefore, and we must upon this occasion, speak of this particular improvement in the management of heat in connection with the mechanical inventions which accompanied and followed it, and to which indeed the former is incidental. For the whole important series of mechanical inventions which I am to recapitulate, the Academy must regret that it has no honors which it can bestow. But their history is upon our records, embodied in the communications addressed to

us by their author from time to time; and we can only hope that the country and the world, when at length sensible of their obligations, may render the tardy meed of justice, if not of gratitude.

In his earliest communication, — a pamphlet published in the year 1845, — Mr. Treadwell seems to think that the appropriateness of the term "useful," as applied to an improvement in implements of destruction, may be questioned. We need have no misgiving in this respect. So long as life and property, which the ravages of war destroy, are not the most valuable of human possessions, they may be justly yielded and taken, if need require, for the preservation of those that are. And so nations must always count among their greatest benefactors those whose inventions increase their strength and defence in war. And certainly those men who, by their inventive genius, revolutionize the art of war, exert a most powerful and enduring influence upon the fate of empires, the course of history, and the progress of civilization.

We in our day, within the last fifteen years, have witnessed a change in the means of attack and defence greater than any made in the two hundred years previous, — a change involving a complete revolution in tactics, both on land and on sea. To take a single illustration from heavy ordnance, — in which the importance of the change impresses us when we are told that our strongest forts, armed with the best guns we had ten years ago, could oppose no effectual resistance to the entrance of such ships as are now built into any of our harbors; and that a ship could now be built and armed, which, singly, would overmatch our whole navy as it was in 1855.

Fortunately, the balance is redressed by equal improvements in defence.

The improvement in fire-arms, both great and small, is in their increased range and precision. When the effective range of a musket-bullet was extended from two hundred yards to fourteen hundred or more, it became imperatively necessary that ordnance should be improved in the same ratio, or it would be useless, as gunners and horses would be picked off by small arms long before they could effectively reach the enemy. This improvement in guns of great calibre has been made, with consequences the importance of which, present and prospective, cannot be over-estimated.

But the point which we have to consider is, that this increased range and precision are entirely dependent on the augmented strength of the gun. The weakness of the gun is the only thing that imposes a limit

to the range short of the absolute strength of the explosive material used. It is the strength of the gun which not only gives the range, but makes rifling possible, with precision and all the advantages of the elongated shot. All inventions relating to the different modes of rifling, the form of the projectile, and the devices for breech-loading, are necessarily subordinate to the question of strength; with this sufficient, those become simple problems, to be rapidly determined by the ingenuity of many inventors.

Now the limit of strength of cast-iron and of bronze cannon had long ago been reached. Excepting Captain Rodman's improvement, and certain modern advantages in working and casting metals, no material advantages had been gained over guns cast in the reign of Queen Elizabeth.

But the most effective guns of the present day embody new principles of strength. They are all *built-up* guns. With them are associated the names of Armstrong, Blakely, Whitworth, Parrott, and others. Whatever may be the relative merits of these several varieties, our interest is confined to the question of their strength, that is, to the principles of construction which have made them stronger than common guns, and rendered their respective subordinate improvements possible. These principles are two, and their introduction at different times into the manufacture of cannon constitutes two successive steps, and the only steps, which give distinctive character to the guns under consideration. Both originated with Mr. Treadwell.

These two inventions are often confounded, although more than ten years elapsed between them. The confusion is doubtless owing in some degree to the fact that the two are found combined in nearly all the modern built-up guns. The first initiated a system of construction which may be designated as the *coil system;* the second, what may be named the *hoop system.*

The first was successfully applied to the making of cannon by Mr. Treadwell in the year 1842, and a full account of it was published in 1845; the gist of the invention being in so constructing the gun that the fibres of the material shall be directed around the axis of the calibre.

This method of construction is described in Professor Treadwell's own language as follows: "Between the years 1841 and 1845 I made upwards of twenty cannon of this material [wrought iron]. They were all made up of rings, or short hollow cylinders, welded together

endwise; each ring was made of bars wound upon an arbor spirally, like winding a ribbon upon a block, and, being welded and shaped in dies, were joined endwise when in the furnace at a welding heat, and afterwards pressed together in a mould by a hydrostatic press of one thousand tons' force.

"Finding in the early stage of the manufacture that the softness of the wrought iron was a serious defect, I formed those made afterwards with a lining of steel, the wrought-iron bars being wound upon a previously formed steel ring. Eight of these guns were six-pounders of the common United States bronze pattern, and eleven were thirty-two-pounders, of about eighty inches' length of bore and nineteen hundred pounds' weight."

The soundness and value of this principle of construction were fully confirmed in England by the experiments of Sir William Armstrong in 1855, and attested by his evidence before a committee of the House of Commons in 1863. He there describes his own gun as one "with a steel tube surrounded with coiled cylinders," — as "peculiar in being mainly composed of tubes, or pipes, or cylinders, formed by coiling spirally long bars of iron into tubes and welding them on the edges, as is done in gun-barrels." His indirect testimony to the originality of Mr. Treadwell's process is equally clear, being that, within his knowledge, no cannon had ever been made upon this principle until he made his own in 1855, — he being, as we must suppose, ignorant of what Mr. Treadwell had done thirteen years before. The statement of Mr. Anderson (witness before the Commons' Select Committee), made before the Institute of Civil Engineers in 1860, is equally explicit as to the nature and value of this method of constructing cannon. And, finally, the high estimate of its importance abroad is shown not only by the honors and emoluments conferred by the British government on the re-inventor, but still more by the actual adoption of this gun as the most efficient arm yet produced. For it must be borne in mind that the faults or failures, complete or partial, of the Armstrong and similar guns are not of the cannon itself, as originally constructed, but of breech-loading contrivances, of the lead coating of the projectile, or of other subsidiary matters.

That our colleague's original invention, the value of which is now so clearly established, should have been so generally unacknowledged by inventors abroad is his misfortune, not his fault. For, not only were his guns made and tested here, and their strength as clearly demon-

strated before 1845 as they have been since, not only was a full account of the process and of the results published here in that year, but a French translation of his pamphlet was published in Paris, in 1848, by a professor in the school of artillery at Vincennes; and Mr. Treadwell's patent, with full specifications, was published in England before Sir William Armstrong began his experiments.

The difficulties to be overcome in making such a gun, — great at all times, as Sir William Armstrong and Mr. Anderson testify, — were far greater in 1842 than in 1863. These difficulties were mainly, if not wholly, in welding large masses of wrought iron in the shape of tubes or cylinders. It is for overcoming these difficulties that this medal is bestowed, and especially for the means and appliances by which this difficult mechanical achievement was effected in the furnace "by the agency of fire."

An incidental but noteworthy part of the improvement was the welding by hydrostatic pressure, — an operation which is just now coming into use in England, but has not yet attracted attention in this country.

We come now to the second improvement in the construction of artillery, — the invention of the *hooped gun*.

This is not always clearly distinguished, even by those occupied with the subject, from the gun formed of coiled rings. But a simple statement will bring into view distinctly the new principle of strength here introduced.

If an elastic hollow cylinder be subjected to internal fluid pressure, the successive cylindrical layers of the material composing it, counting from within outwards, will be unequally distended, and the resisting efficiency of the outer layer will be less than that of any layer nearer the axis. And if the walls of the cylinder are thick, and the internal pressure surpasses the tensile strength of the material, its inner layer will break before the outer one has been notably strained. Hence the tensile strength of a square inch bar of the material is the measure of the maximum pressure the cylinder can bear, when constructed as guns were before the introduction of the improvement now under consideration. The improvement does away with this limit, and enables us to go indefinitely beyond it.

This is accomplished by so constructing the gun that the inner layers are compressed by the outer; whereby the internal pressure is first resisted by the outer layers, which must be distended enough to allow

the internal compressed portion to attain its normal condition before this internal portion (which is the first to break in the common gun) is subject to any strain at all. It will be perceived that if this principle could be rigorously applied, a cannon could be made so perfect that, when subjected to a bursting pressure, every fibre, from the internal to the external surface would be at that instant equally extended, each contributing its full share of resistance to fracture. The whole resistance would be proportional to the area of fracture.

This was supposed to be the case in common cylinders, before the error was pointed out by Barlow, and also by Lamie and Clapeyron. And it was this erroneous supposition that led Count Rumford to his exaggerated estimate of the force of gunpowder, as tested by its power of bursting gun-barrels. If he had used the theory which gave origin to the hooped gun, his results would nearly have agreed with modern observations.

The demonstration of the superiority of the hooped gun, with detailed directions for its construction, is contained in a paper read before this Academy in February, 1856, and published at the beginning of the sixth volume of our Memoirs. This was the first published account of the invention, which had been patented nearly a year before. Captain Blakely's pamphlet, published in England in 1858, sets forth the advantages of this construction by similar arguments; as also does an elaborate paper read by Mr. Longridge before the Institution of Civil Engineers in February, 1860. . Both these gentlemen, however, were engaged in researches upon this subject at an earlier date, but not so early, it would appear, as was Mr. Treadwell.

The validity of the principle, and the soundness of Mr. Treadwell's views upon the whole subject, as set forth in his memoir, have been amply confirmed by special experiments made in England with the Blakely and Whitworth guns, and by experience in this country during the last four years with the Parrott and the Blakely guns.

It must not be supposed that the earlier invention is superseded by the later one. That is used in forming the hoops of the Parrott gun, and in most of the British guns. And the best gun which could now be made, as experience has shown, would be composed of a barrel of cast-iron or steel, enclosed and compressed by a cylinder of coil.

We need not discuss the question of priority of invention between Mr. Treadwell and others, competitors for a share in the honor of producing the modern cannon. His independence of each and all of them

has never been called in question. Nor will it ever seriously be thought that the previous futile attempts at constructing wrought-iron and banded guns, — foredoomed failures both in theory and practice, and destitute of all pretension to a knowledge of the guiding principles now clearly seen to be essential to success, — should detract in the slightest degree from the great honor which our associate has, by a clear insight into the conditions of the problem and the resources of physical science, so fairly and completely won.

Upon these two inventions has been set the seal of experience. But there is still another memoir, read by Professor Treadwell before this Academy in April, 1864, and printed soon afterwards, which promises to add a third important improvement in the construction of artillery.

Perceiving that the body of a hooped gun, if made of unmalleable cast-iron, compressed by a soft wrought-iron hoop, must give way, by the fracture of the cast-iron, before the hoop can approach the ultimate limit of its strength, and that this was, in fact, a principal cause of the failure of so great a part of the large guns of Blakely and Parrott, Professor Treadwell, as the principal result of this third investigation, proceeds to show, that, to attain with effect the end sought for by hooping a cast-iron gun, it is necessary to harden the wrought-iron hoop by cold hammering and severe stretching before placing it upon the gun-body. He computes, that, by this simple means, a hooped gun may be made *more than twice as strong* as those which have been constructed by Blakely and Parrott, the materials being in both cases the same.

In this important discovery, as also in other matters discussed in his latest memoir, we are gratified to see, that, although now carrying the weight of more than threescore and ten years, our veteran colleague still keeps the lead, which he gained at the start, of his competitors in this race of improvement.

So completely do these three improvements cover the ground, that if the works of all other inventors who claim a share in the great gun of the nineteenth century were lost, the gun could be restored (rifling excepted) from Mr. Treadwell's papers alone.

And now, Mr. Treadwell, in delivering into your hands this beautiful gold medal and its silver duplicate, I have much pleasure in conveying with them the congratulations and best wishes of your associates here assembled; also the expression of their hope that you may yet longer lead the race; and especially that you may long enjoy the

scientific honors which you have worthily won; and with them, if it may be so, the full recognition of the rights, and possession of the advantages, which pertain to your inventions.

On receiving the medal, Mr. Treadwell expressed his acknowledgments as follows: —

Mr. President and Gentlemen of the Academy: —

I receive with great satisfaction the Rumford Medal which, in accordance with a vote passed at the Annual Meeting, you have now presented to me. I prize this premium the more as coming from this body, with which I have been intimately associated for more than forty years as an active member, and for a very large part of the time as an office-bearer. I may be permitted to say, however, that, although I am sensible that I am indebted for this award in a large degree to your kind partiality for an old associate, which turned your attention to his labors, yet it was made not only without any application on my part, but your motion towards it was wholly unknown, and not even thought of by me, until the vote of the Rumford Committee was communicated to me.

The award was, as stated in your vote, (which uses the language of Count Rumford,) for "improvements in the management of heat." But as this management of heat was incidental to, and intimately connected with, improvements in the construction of cannon, to which I had given years of labor, you have extended your examination into the character of those improvements generally. For the very thorough research which it is evident you have made into the whole subject, I feel under great obligations to you; and the very favorable conclusions which you have reached, and which have been so fully and kindly expressed by you, Sir, as to the originality and value of my researches and labors, form an additional source of satisfaction to me. This, taken alone, would constitute one of the most welcome recognitions and rewards that could be given to me. Permit me, in conclusion, to express my special obligations to the members of the Rumford Committee for directing their attention to my labors, and for the very favorable view which they have taken of their merits.

The President then introduced Dr. Burt G. Wilder, who presented the following communication: —

On the Nephila Plumipes, or Silk Spider. By BURT G. WILDER, S. B., late Surgeon 55th Mass. Vols.

AT the north end of Folly Island, which lies just south from the harbor of Charleston, S. C., on the 20th of August, 1863, I found in a tree a large and very handsome geometrical spider, whose web was about three feet in diameter. While examining the insect at my tent, it occurred to me to see how much of the silken thread could be drawn from the spinners. As it was not disturbed by pulling out a few yards, I wound the thread around a quill, and then, by turning this in my fingers, reeled off silk from the body of the spider for one hour and a quarter, at the rate of six feet per minute, making one hundred and fifty yards of most beautifully shining golden silk. This specimen is still in my possession, and, having been removed from the quill, weighs one third of a grain. I had never before seen this spider, nor had I ever heard of this method of obtaining a silken material; but when, during the following summer, another officer of our regiment * described to me a large spider as very common upon Long Island, which lies just west from Folly Island, I knew it was the same, and told him what I had done, adding that I was sure something would come of it in time. By substituting a cylinder worked by a handle for mine turned in the fingers, this officer obtained more of the silk, winding it upon rings of hard rubber, and afterward, by using a "gear-drill stock," another officer † accomplished similar results still more rapidly.

With this "gear-drill stock" I wound from a number of spiders *three thousand four hundred and eighty yards* of silk upon the periphery and over the sides of a hard rubber ring; the length being accurately measured by multiplying the dimensions of the ring where wound upon by the number of revolutions per minute, and this product by the number of minutes of actual winding. This was in the fall of 1864, and in February, 1865, I showed specimens of the spider and of the silk to Professors Wyman, Agassiz, and Cooke of Harvard University, neither of whom had ever heard of this way of obtaining silk, nor, with the exception of Professor Wyman, — who found a single individual among some specimens collected at the South, — had they ever seen the insect. At this time, too, a friend ‡ to whom the whole history of the

* Major Sigourney Wales, 55th Massachusetts Volunteer Infantry.

† Lieut.-Col. Charles B. Fox, 55th Massachusetts Volunteer Infantry.

‡ Dr. William Nichols of Boston.

matter was known, expressed his confident belief that this new silken product could be made of some practical utility, especially in view of the anticipated scarcity of ordinary silk; and it is in great measure due to his advice and assistance that the experiments and investigations recounted below have been made.

The only mention of this spider is in the German work of C. L. Koch, "Die Arachniden," where in Vol. VI. is described, under the name of *Nephila plumipes*, a mutilated female specimen, the only one ever collected, and which is preserved in the museum of J. Sturm at Nuremberg. This description and its accompanying figure are very imperfect, but until a careful comparison can be made between the original specimen and some of my own, I will consider the latter as representatives of *N. plumipes;* though an accurate description and figure shall be made as soon as possible.

The following general description applies only to the females, the males being very small and of a different color.

NEPHILA (PLUMIPES?) Koch. A large and very elegant species of *Nephila*, resembling most of its congeners in the general form of the body, and, like *N. clavipes* and *N. fasciculata*, possessing peculiar collections of stiff hairs upon the legs, but differing from these two species in that these hairs are more closely set so as to justify the German term "Haarbürste" (Hair-brushes).

In general the cepalo-thorax is black above, but covered, except in spots, by silver-colored hairs. The abdomen is olive-brown, variously marked with yellow and white spots and stripes. On the first, second, and fourth pair of legs are one or two brushes of stiff black hairs pointing outward away from the body. The length of the body is one and one tenth inches, and the spread of the legs from two and three fourths in a lateral, to three and three fourths inches in a longitudinal direction. The length of the body of the male is about one third of an inch, and his general color is brown. His palpi are clubbed near the extremities, and end in a sharp point turning outward.

With the exception of the first and only specimen discovered upon Folly Island, and a cocoon found on James Island, I have met with this spider only upon Long Island and one or two similar bits of land in the vicinity. They are all low, sandy, and marshy, covered with palmetto and pine trees, uninhabited, and apparently never before visited by naturalists.

These spiders are specially abundant upon Long Island, and are

found in large geometrical webs, two, three, or four feet in diameter, stretched between shrubs or trees, and often high up among the pines, so as to be out of reach. The webs are strong and of a yellow color; and, as with most species of geometrical spiders, the concentric circles are elastic and studded with numerous viscid globules, while the radii and other parts of the framework are composed of dry and inelastic silk; but with this species the distinction between these two portions of the web consists not only in the viscidity of the former, but also in the color; for while most of the concentric circles are of a bright yellow or golden hue, the radii and stay-lines, and also *every eighth or tenth circle* (the number varies in different individuals), are white or silver-colored. The circles are very near together in proportion to the size of the insect, being only one third or one fourth of an inch apart.

As might be inferred from these facts, but which, so far as I know, has never before been observed, this spider not only has the power of regulating the *size* of its thread, — according as one or two, or three or four of its spinnerets are pressed upon the surface from which the line is to extend, or as a greater or less number of the spinnerules in any one spinneret are employed, — but can also use in the construction of its web either the white or the yellow silk at will; for of its two principal pairs of spinnerets, one, the anterior, yields the yellow, while the other or posterior pair yields the white silk. Of this I satisfied myself by carrying the thread from the anterior pair of spinners upon one part of a spindle, and that from the posterior pair upon another part, guiding them with pins while the spindle was in motion; the result being the formation of two circles of silk, one of a golden, the other of a silver color, as in one of the specimens exhibited; moreover, if while both threads are being drawn out, they are slackened, the lower silver thread will wrinkle and fly up, being inelastic; while the other will contract and, within certain limits, preserve its direction.

There is a corresponding difference in the color of the glands which secrete the gum of which the silk is formed; one set, the more numerous, being yellow, and the other white.

The manner in which the spider deposits the globules of gum on the circles which she wishes to be viscid is not yet explained; at any rate this same yellow silk, when either reeled from the body of the spider, or when employed in the formation of its cocoon, is *dry* and *much less elastic* than that of which the concentric circles are composed.

The evolution of the silk from the spider is almost wholly a mechan-

ical process, and, beyond a certain expansion of the parts, by separating the spinners from each other, the only control exercised by the insect is by means of its hinder legs, the tips of which serve to guide the thread, and by grasping it to control the evolution. I have never been able to reel out over three hundred yards at once from a single spider; but on opening the abdomen, the glands are found still to contain more or less gum. Upon three successive days I obtained equal quantities of silk; so that if, as now seems probable, the emission of the silk is purely mechanical, then a certain degree of preparation is necessary, after it is secreted, before it is ready for use.

The diameter of the silk as spun by the insect, or as reeled from it, varies from one six-thousandth to one thousandth of an inch;* it is exceedingly strong, more so in proportion to its bulk than that of the silk-worm; as is natural, since the spider's thread is made up of hundreds and even thousands of minute fibrils, while the common silk is single. The largest threads are those composing the outer layer of the cocoons, but these are evidently compound, and each of the two, three, or four strands is apparently such as proceeds from the single spinners; the minute fibrils of which have united at once on leaving the spinnerules, so as to form the ordinary silken fibre which generally appears simple under the microscope.

The habits of this spider are very interesting. It seems to obey three principal instincts: first, to ascend; second, to seek the light, whether natural or artificial; and, third, to maintain a position with the head downward. It has eight eye-spots, but, so far as I have observed, it can only distinguish light from darkness, and is not able to see objects. There is not here space to give in detail an account of all that I observed in case of several which made their webs in my room in South Carolina; but all seems to indicate that these spiders do not *see*, as the term is generally understood; the touch is, however, very acute, and is exercised by the palpi and by the tips of the legs, specially the anterior pair. Unlike some other geometrical spiders, it seizes its prey at once in its jaws, and never envelopes it in a silken net till it has expired. The sense of hearing is evidently very acute.

It is very quiet in its disposition, and never leaves its web unless molested. The female builds the web, and even carries the male on her back or belly when moving about; she never attempts to bite

* The micrometer measurements were made by Mr. R. C. Greenleaf.

unless provoked, and may be suffered to run over one's person with impunity.

Perhaps the most remarkable fact in connection with this spider is, that it can be *fed and watered by hand;* a live fly held to its jaws is seized as soon as a buzz makes its presence known; so also a bit of chicken-liver, if touched to the jaws; and if a drop of water be presented on a camel's-hair pencil, it will be readily taken and gradually swallowed. It is evident that the spiders drink the drops of water which are left in the web from the rain or dew; and they thrive best in a moist atmosphere.

The female lays four or five hundred eggs, half as large as a pin's head, and slightly agglutinated together in a rounded mass, which is secured on the lower side of a leaf by a strong silken cocoon of loose texture, and varying in color. Many of the eggs which were laid by my spiders in September were hatched in about thirty days. The young differ much from the adult in form and color; and the changes which they pass through in growth will prove a most interesting branch of the subject. The young do not leave the cocoon for some time; and even after they have, are more or less gregarious, — always keeping in companies, and preserving good order while moving. They need water, and, if not supplied with food, are prone to eat one another. If properly attended to, they grow quite rapidly;* and although at first they make only an irregular web in common, yet after they have attained a length of half an inch, they will, if separated, construct regular geometrical webs.

In a state of nature, not many over one per cent of the spiders which are hatched live to maturity; so that the question of a practical value of this silk depends upon the success of the attempts to prevent this destruction, which is apparently due to their own voracity, to the elements, and to other insects.

Much more might be related concerning the habits of the insect, of the manner of keeping and feeding the young, of the means of securing the spider while its silk is obtained, and of the various apparatus employed; but I am so impressed with the peculiarities thus far observed in themselves, and with the beauty and strength of the silk, that if time and means permit I shall continue the inquiry as far as possible. And having now, as I hope, established my claim to the

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* Feb. 23d, 1866. Some of these young are now more than an inch in length.

discovery of this new method of obtaining a silken material, (namely, by a reeling or circular motion applied to the insect itself,) I will defer to a future occasion a more complete account of the spider, of its habits, anatomy, and embryology, and of the various qualities of its silk, with whatever conclusion can be reached concerning the practicability of rearing the young; and also how far it is possible to apply the same process to the silk-worm, and other silk-producing larvæ.

Five hundred and fifty-ninth Meeting.

December 12, 1865. — MONTHLY MEETING.

The PRESIDENT in the chair.

A letter was read from Mr. Samuel Eliot in acknowledgment of his election into the Academy; also letters relative to exchanges.

The President called the attention of the Academy to the recent decease of Dr. John Lindley of London, of the Foreign Honorary Members.

Five hundred and sixtieth Meeting.

January 9, 1866. — MONTHLY MEETING.

The PRESIDENT in the chair.

The President called the attention of the Academy to the recent decease of Colonel James Duncan Graham of the Resident Fellows, formerly an Associate Fellow.

A memoir by Professor Child was presented by title, namely, "Remarks on the Language of Gower's *Confessio Amantis*: a Sequel to Observations on the Language of Chaucer, printed in Vol. VIII. of the Memoirs of the Academy."

Professor Cooke made the following communication: —

On the Aqueous Lines of the Solar Spectrum. By JOSIAH P. COOKE, JR.

A CAREFUL examination of the solar spectrum, continued during several months with the spectroscope described in a recent article of the

American Journal of Science,* has led me to the conclusion that a very large number of the more faint lines of the solar spectrum, hitherto known simply as *air* lines, are due solely to the *aqueous vapor* of our air, and hence that the absorption of the luminous solar rays by the atmosphere is at least chiefly owing to the aqueous vapor which it contains.

The appearance of the Fraunhofer's line D, seen under precisely the same conditions, but with increasing quantities of aqueous vapor in the atmosphere, is shown in Figures 1, 2, 3, and 4. The D line is selected, because, being a favorite test object for the spectroscope, its general appearance is well known to all observers. But even more marked changes than those here illustrated have been noticed in other, although chiefly in contiguous, portions of the solar spectrum.

These changes attracted my attention from my earliest observations with the spectroscope; but with my first instrument, and the bisulphide of carbon prisms then employed, it was almost impossible to eliminate the effects which might be caused by the variations in the condition of the instrument itself; and as these were known to be very great, it was possible that they might account for all the variations observed. With the improved instrument, however, just referred to, absolute constancy of action is obtained, and all merely instrumental variations avoided.

A peculiar condition of the atmosphere gave the first clew as to the cause of the changes under consideration. The weather on the 17th of November, 1865, at Cambridge, Massachusetts, was very unusual even for that peculiar season known in New England as the Indian Summer. At noon the temperature on the east side of my laboratory was 70° F., while the wet-bulb thermometer indicated 66°, showing an amount of moisture in the atmosphere equal to 6.57 grains per cubic foot. At the same time the atmosphere was beautifully clear, and the sun shone with its full splendor. I have never seen the aqueous lines of the spectrum more strongly defined than they were on this day; and the total number of lines visible in the yellow portion of the spectrum was at least ten times as great as are ordinarily seen. The appearance of the D line on that day is shown in Fig. 4. Between the two familiar broad lines D_1 and D_2 there were eight sharply defined lines of unequal intensity, which is only very imperfectly represented by the woodcut. In addition to these, on the more refrangible side of the space

* American Journal of Science and Arts, Vol. XI., November, 1865.

between the two D lines, there was a faint but broad nebulous band, barely resolvable into lines of still smaller magnitude.* It is impossible to represent this band accurately with a woodcut; and the shaded broad band marked κ on the right-hand side of Fig. 4 only serves to indicate its position and approximate breadth.

The 26th of December was also a warm day for the season, with a brilliant sun. At one o'clock, P. M., the dry-bulb thermometer marked 55°, the wet-bulb 50°, and hence the amount of moisture in the atmosphere was 3.76 grains per cubic foot. The appearance of the D line at this time is shown in Fig. 3. Two of the lines, η and θ, and the nebulous band κ, seen on the 17th of November, were invisible, and moreover the group of three lines δ ϵ ζ on the left-hand side of the figure were only just within the limits of visibility.

On the 25th of December only two lines were visible within the D line, marked α and β, in Fig. 2, and the last of these was quite faint. The temperature at the time of observation was 46°; the wet-bulb thermometer indicated 40°, and the amount of moisture in the air was 2.42 grains per cubic foot. The sky was clear and the sun brilliant. Lastly, on January 5th, 1866, one of the clear cold days which are so common in our climate during the winter, only the single line α was visible within the D line, as is shown in Fig. 1. At the time of observation, near noon, the dry-bulb thermometer marked 10°, the wet-bulb 9°, and hence the amount of moisture in the atmosphere was only 0.81 of a grain per cubic foot. The sun, however, was as brilliant as in either of the previous cases. The D line also appeared as in Fig. 1 on the 8th of January, 1866, when the thermometer at noon stood at 10° below zero Farenheit, and when the barometer attained the unexampled height of 31 inches.

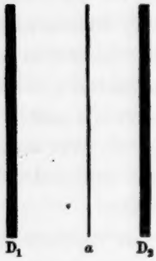
The above figures have been drawn so as to show, as nearly as possible, the relative intensity of the different lines under different atmospheric conditions. As no accurate means of making the comparison are yet known, I was obliged to depend upon my eye alone, and small differences at different times of observation may easily have escaped my notice. Indeed, I should have been liable to great error, were it not for the fact that one of the lines within the D line, marked α in all the figures, does not vary in intensity, and served as a constant standard in making the observations. This is the only line which is given

* We use this word in the same sense in which it is used by astronomers with reference to the fixed stars.

January 5*th*, 1866.

Temperature 10° F.
Dew-Point 1°.5 F.

FIG. 1.



Weight of vapor in 1 cubic foot of air, } 0.81 grs.

December 25*th*, 1865.

Temperature 46° F.
Dew-Point 33°.4 F.

FIG. 2.

Weight of vapor in 1 cubic foot of air, } 2.42 grs.

December 26*th*, 1865.

Temperature 55° F.
Dew-Point 46°.5 F.

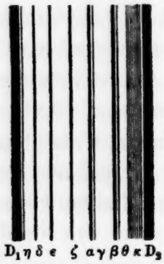
FIG. 3.

Weight of vapor in 1 cubic foot of air, } 3.76 grs.

November 17*th*, 1865.

Temperature 70° F.
Dew-Point 64°.0 F.

FIG. 4.



Weight of vapor in 1 cubic foot of air, } 6.57 grs.

by Kirchoff in his chart of the solar spectrum between the two D lines, and it is referred by him to the Nickel vapor, — as the D lines themselves are to the Sodium vapor, in the sun's atmosphere. It is an undoubted solar line, and has been drawn with the same strength in all the figures in order to show that it is invariable.

With a very dry atmosphere the line α is the only one which appears within the D lines, as shown in Fig. 1. With a slightly greater amount of vapor the line β makes its appearance. As the amount of vapor continues to increase, this line becomes more and more prominent, until at last, as shown in Fig. 4, it is even more intense than the line α. A careful comparison of these two lines might indeed serve as an approximate measure of the amount of vapor in the atmosphere; and a series of comparisons made under the same conditions at different heights would give data for determining the law according to which the amount of vapor decreases with the elevation above the sea level.

All the aqueous lines change in intensity like the line β. They are first seen very faintly when the amount of vapor in the air reaches a definite point, varying for the different lines, and gradually gain in intensity as the amount of vapor increases. Thus the group of three lines $\delta\ \epsilon\ \zeta$ do not appear in Fig. 2, are barely visible in Fig. 3, but become very marked in Fig. 4.* The lines η and θ and the nebulous band κ do not appear until the air is very moist; and even when it contains 6.57 grains of vapor per cubic foot, they are still very faint. Under yet more unusual atmospheric conditions they will undoubtedly become more intense, and we shall then probably be able to completely resolve the nebulous band and count the lines of which it consists.

It is hardly necessary to repeat, that the examples here given are selected from a large number of observations. During the cold dry weather of winter the appearance of the D line is uniformly as shown in Fig. 1, the line β only occasionally appearing when the atmosphere becomes more moist. During the warm weather of summer, when the absolute amount of moisture in the air is in almost all cases greater than in winter, the appearance of the D line is as uniformly that shown in Fig. 3. It is only very rarely in the dry climate of New England, even during the summer, that all the lines shown in Fig. 4

* With an increasing quantity of vapor in the atmosphere the line γ of Fig. 3 is seen before the group of lines $\delta\ \epsilon\ \zeta$, and an intermediate figure between 2 and 3 might be given showing only the lines $D^1\ \alpha\ \gamma\ \beta\ D^2$.

are visible; and, as already stated, I never before saw them so sharply defined as on the 17th of November last.

Several conditions must evidently concur in order that the aqueous lines should be developed in their greatest intensity. In the first place, the air must be charged with vapor not only near the surface of the earth, but also through a great height of the atmosphere. Local causes might greatly increase the amount of moisture in the lower strata of the atmosphere, and affect powerfully the hygrometer, which would not, to the same extent at least, influence the indications of the spectroscope. In the second place, other things being equal, the intensity of the aqueous lines must be strengthened by increasing the length of the path of the sun's rays through the atmosphere, and this is the longer the lower the altitude of the sun. But then, again, the intensity of the light has such an important influence on the definition of the lines, and the slightest haze in the atmosphere so greatly impairs their distinctness, that I have generally found that the aqueous lines are seen best when the sun is near the meridian. Hence, with an equal amount of moisture in the atmosphere, the late autumn may be a more favorable season for seeing the aqueous lines than the summer; for then not only must the solar rays, when most brilliant at noon, traverse a greater extent of air, but, moreover, the atmosphere at this time is usually clearer, and the reflected beam of light which enters the spectroscope is at times more brilliant than when the sun attains a higher elevation and the light is reflected under less favorable conditions.

In the examples cited above, the comparisons were made under as nearly as possible the same conditions, so as to eliminate all causes of variation except the one under consideration. Days were selected when the atmosphere was perfectly clear, and the sun's light, so far as I could judge, equally brilliant. Moreover, the position of the spectroscope and mirror remained unchanged during the whole time. This mirror, which is used for reflecting the sun's light upon the slit of the spectroscope, is so arranged that it can be turned into any position by the observer while his eye is at the eye-piece of the spectroscope, and it was always carefully adjusted at each observation to the position of best definition. The manipulation of the mirror is fully as important in the use of the spectroscope as it is in microscopy.

It will be of course understood that the power of developing these faint aqueous lines depends very greatly on the optical capabilities of the spectroscope, and that the figures here given are relative to the

instrument used in the observations. This instrument has been fully described in the article already cited. It is sufficient for the present purpose to state that it is provided with nine flint-glass prisms* of 45° refracting angle, which bend the rays of light corresponding to the D line through an angle of 267° 37′ 50″, and that corresponding to the H_1 line through an angle of 280° 42′ 20″, when each passes through the prisms at the angle of minimum deviation. The dispersive power of the instrument for these two rays is therefore equal to 13° 4′ 30″, and the rays corresponding to the two D lines are separated 1′ 10″. The object-glasses of the two telescopes of this spectroscope are 2¼ inches in diameter, and have a focal length of 15½ inches, and lastly the size of the prisms, and of the various parts of the instrument, is adapted to these dimensions. With a more powerful instrument a larger number of aqueous lines would be seen under the same atmospheric conditions. The Cambridge instrument has a set of sulphide of carbon prisms which disperse the light nearly twice as much as the flint prisms. The sulphide of carbon prisms are very variable in their action; but, under the best conditions, they might show the D line as in Fig. 3, when with the flint prisms it would appear as in Fig. 2.

The facts stated in this paper fully account for the discrepancies in the representations which different observers have given of the D line. Some time since, Mr. Gassiot, of London, gave in the Chemical News a representation of the D line as seen with his instrument, showing several lines in addition to those seen by myself and other observers. On visiting the Kew observatory, in the summer of 1864, I was surprised to find that this instrument was less powerful than the one I was then using; and I also learned that these lines were only seen on a single occasion. The moist climate of England is the evident explanation of the additional lines.

As I stated at the first of this paper, the D line has been selected simply to illustrate a general truth. The development of aqueous lines in contiguous portions of the spectrum is even more marked than in the exceedingly limited portion here represented. Indeed, as has been already intimated, the number of these lines seen in the yellow region of the spectrum, on the 17th of November, was at least ten

* These prisms were furnished by the American Academy from the income of the Rumford Fund, appropriated for investigations on light and heat. See Proceedings of the American Academy, Annual Meeting, May 24th, 1864.

times as great as that of the true solar lines. That part of the yellow of the spectrum which lies on the more refrangible side of the D line, and in which during dry weather only a comparatively few lines can be distinguished, was then as thickly crowded with lines as the blue or the violet, but the lines were of course far less intense.

Professor Tyndal, of London, has shown by a remarkable series of experiments with the thermo-multiplier, not only that aqueous vapor powerfully absorbs the obscure thermal rays, but also that the elementary gases of the atmosphere exert little or no action upon them. I have endeavored to establish in this paper, from direct observations with the spectroscope, a similar truth in regard to the luminous rays. It has been estimated by Pouillet and others that about one third of the solar rays intercepted by the earth are absorbed in passing through the atmosphere; and it now appears that aqueous vapor is a most important, if not the chief, agent in producing this result. It is impossible, however, from any data we yet possess, to determine how great a power of absorption is exerted by the oxygen and nitrogen gases which constitute the great mass of our atmosphere. I have shown that a very great many, and I have no doubt that almost all, the lines hitherto distinguished as air lines are simply aqueous lines; but it is very difficult to distinguish atmospheric lines from the true solar lines, and our knowledge of the first is as yet very incomplete. It still remains to make careful comparisons throughout the whole extent of the spectrum, before we can absolutely determine the relative absorbing power of the different constituents of our atmosphere.

One other inference from the facts here developed is worthy of notice before closing this paper. It has been for some time suspected that the blue color of the sky was in some way connected with the vapor in the atmosphere; and it is a fact of common observation, that this color is more intense during the moist weather of summer than during the more dry weather of winter. The distribution of the aqueous lines through the solar spectrum not only confirms the opinion previously entertained, but also points to the cause of the color. So far as my observations have extended, the aqueous lines are almost wholly, if not completely, confined to the less refrangible portion of the spectrum. Here they are found in vast numbers, and I am not positive that they exist anywhere else. If, then, the aqueous vapor absorbs most powerfully the yellow and red rays of the spectrum, the blue color of the sky is the necessary result. The color is therefore due to simple absorption,

and not to repeated reflections from the surface of drops of water, as some physicists have supposed.

As can readily be seen, the aqueous lines of the solar spectrum present a very wide field for investigation, but one which can only be cultivated under peculiar atmospheric conditions. This paper is only intended to open the subject. I hope to be able to continue the study on every favorable opportunity, and shall take pleasure in communicating any future results to this Academy.

Professor Charles W. Eliot exhibited to the Academy a dynamometer invented by Mr. S. P. Ruggles, the Curator of the Museum of the Institute of Technology.

"This new and admirable invention accomplishes two objects; — first, it measures the exact amount of power which is being consumed in driving a single machine, or any number of machines, at any instant of time, indicating every change in the force required, as the work done by the machines varies from instant to instant; secondly, the apparatus adds up and registers the total amount of power which has been used by any machine, or set of machines, during a day, a week, a month or any desired time. The apparatus may be thus described. The pulley, from which the power is taken, is attached to the shaft by the intervention of a spiral spring. One end of this spring is secured to the shaft, and the other end to the hub of the pulley. The lateral motion of the pulley upon the shaft is prevented by a collar on either side of the pulley. On the inside of the hub is cut a screw of about three-inch pitch, that is, a screw which makes a complete turn within a distance of about three inches measured on the axis of the hub. A rectangular slot is cut out of that part of the shaft which lies within the hub of the pulley, and in this slot slips backwards or forwards a piece of metal which precisely fits the slot. From each side of this small piece of metal there projects beyond the surface of the shaft a small portion of the male screw which exactly fits into the screw cut in the interior of the hub of the pulley. If there be no resistance at all to the motion of the pulley, the shaft, spring, and pulley will all start together, and revolve together. But if a resistance be offered to the motion of the pulley, the shaft, and with it the piece of metal which slips in the slot, will start first, and the pulley will move only when the strain caused by the twisting of the spring is sufficient to overcome the resistance applied to the circumference of the pulley. But if the piece of metal in

the slot begin to turn while the hub of the pulley is stationary, the piece must move laterally within the slot, being forced by the screw. If the pulley start a quarter of a turn later than the shaft, the piece will move laterally three quarters of an inch; if the pulley start a half a turn later than the shaft, the piece will move laterally an inch and a half. The lateral motion of the piece in the slot is proportional to the retardation of the pulley, and this retardation is proportional to the strain upon the belt which passes over the pulley, and conveys the power to be used. To the movable piece in the slot is connected a small round rod, which runs out through the centre of the main shaft and projects some little distance beyond it. On the end of this rod is a circular rack of teeth, in which plays a pinion, on whose shaft is a hand moving over a dial-plate. By applying strains, measured by standard scales, to the belt which passes over the pulley, — as a strain of ten pounds, fifty pounds, one hundred pounds, — it is easy to graduate the dial-plate into pounds, so that the number of pounds of strain upon the belt may be read off at any instant by a mere inspection of the dial. The mode of operation of this part of the apparatus is then as follows: — when no power is being conveyed from the pulley, shaft and pulley start simultaneously; there is no lateral motion of the piece within the slot and its connected rod, and the hand on the dial points to zero. But the moment that power begins to be expended in driving the machinery, the strain upon the belt will be first felt by the spring which connects the pulley to the main shaft, and the spring will yield in proportion to the strain; the effect is to let the shaft make a small part of a revolution in the hub of the pulley, before the pulley begins to turn and keep pace with the shaft; the rod within the end of the shaft is thus drawn in a little, the hand moves over the dial-plate, and points to the exact number of pounds of power which the belt is conveying from the pulley at the instant of observation.

The registering of the total amount of power delivered from the pulley is effected by means of two small belts running over the round rod, which projects beyond the end of the main shaft and carries the index hand above described. These two small belts communicate the motion of the shaft to two parallel and equal wheels, one of which bears a dial-plate, and the other an index hand which moves over the dial-plate. When there is no strain upon the main belt going over the pulley, the two wheels revolve at the same rate, — neither gaining upon the other, and the hand remains constantly

over the same figure on the dial-plate; but when a strain is put upon the belt and the round rod moves laterally, as above described, the lateral motion brings a conical enlargement of the rod under the little belt which moves the wheel bearing the dial. The dial-wheel now goes faster than the wheel carrying the hand, and begins to count up the power used. The greater the lateral motion of the rod, or, in other words, the greater the power transmitted to the working machines, the larger the diameter of the cone which comes under the belt of the dial-wheel, and the greater the gain of the dial upon the hand. The wheels of both dial and hand are constantly revolving in the direction opposite to that of the motion of the hands of a watch. The belt of the hand-wheel runs always upon the rod, where its diameter is constant, and as the rod moves laterally under the little belts, guides are necessary to keep the belts themselves from moving laterally also. The proportions of the cones on the rod, and of the two wheels which carry the dial and the hand, can be so adjusted as to make a difference of one complete revolution between the motions of the hands and of the dial indicate a delivery of ten thousand foot-pounds, or of ten million, or of any other convenient number, and, by a system of gearing analogous to that used in gas-metres, any desired amount of power could be consecutively registered. It is obvious that the registering apparatus takes account of both the strain and the speed, while the simple index first described measures only the strain.

This instrument is at once elegant in design, simple and therefore cheap in its construction, easily verified and proved at any moment when in operation, and of very easy application to any machine, or set of machines, driven by hired power, whether the power used be constant or variable in amount. The instrument admits of a great variety of forms: the one described above is meant for the end of a shaft; another form is so arranged as to be attached at any part of a running shaft, while in the proportions and dimensions of the several parts there would be the same variety as in common scales, which are large or small, coarse or fine, according as they are meant to weigh coal or pills, hay or coin. The instrument meets a pressing want. Tea and sugar are sold by the pound, gas by the thousand feet, cloth by the yard, but steam-power and steam and air engines are sold by guesswork, or by rough and uncertain rules, on whose application buyer and seller can seldom agree.

Hereafter steam-power can be sold by the thousand or million foot-pounds.

Mr. Ruggles does not patent his valuable invention.

Dr. Jeffries Wyman presented the following paper: —

Notes on the Cells of the Bee.

It is more than a century and a half since Maraldi studied the form of the cells of the hive bee, and described them as hexagonal prisms with trihedral bases, each face of the base being a rhomb, the greater angles of which were 109° 28′, and the lesser 70° 32′.* Twenty-five years later, Reaumer, the most admirable of the observers of insect life, with the view of ascertaining how far such a form was an economical one, proposed to Koenig the following problem, — "Of all hexagonal cells, having a pyramidal base composed of three equal and similar rhombs, to determine that which can be constructed with the least amount of material." † It is a part of the history of this subject, that Koenig's results differed from those of Maraldi by two minutes in each of the angles, the former having made them 109° 26′ and 70° 34′. It has recently been stated that the table of logarithms used by Koenig had an error which would exactly account for the difference.

Admitting an error of two minutes in each of the angles, still the close correspondence between the results of Koenig and the measurements of Maraldi was well fitted to excite the wonder and admiration of all, and from that time to this the belief has prevailed, that the instinct of the bee enables it to construct such a cell as that sought in Reaumer's problem, if not in all cases, at least in the larger portion of them, without sensible error. It were unjust to keep out of sight the fact, that, however correct the measurements of Maraldi may have been, he has left no record of his method of making them, and furthermore, the possibility of measuring the angles of such a structure as the cell of the bee, without liability to an error of one or two degrees in each angle, is denied by competent authorities, since the angles of the cell are nowhere sharply defined and the surfaces are not strictly planes. ‡

* *Mem. Acad. des Sciences*, 1712.

† *Memoires pour servir à l'Histoire des Insectes*, Tom. V. p. 389. Paris, 1740.

‡ The first person who appears to have called Maraldi's measurements in question was Father Boscovich, "who had supposed that the admeasurement of the angles was too nice to be accurately performed, and that the coincidence of M.

The mineralogist, treating the cell as a crystalline form, would not expect a closer approximation to exact measurement than that just stated.

Lord Brougham, who, of later writers, has written the most elaborately on the subject, in his essay entitled *Observations, Demonstrations, and Experiments upon the Structure of the Cells of Bees,* after having himself solved Reaumer's problem, after having obtained solutions of it through others, and after having himself measured the cells, asserts positively that they are constructed in accordance with the form deduced from calculation, and are therefore exact. Having compared the sides of the cell by measurement with a micrometer, he says, "I certainly can find no inequality." * Again, "She [the bee] works so that the rhomboidal plate may have one particular diameter and no other, always the same length, and that its four angles may be always the same"; † and he still further adds, "The construction of the cell, then, is demonstrated to be such that no other which could be conceived would take so little material and labor to afford the same room." ‡

We have looked carefully through Lord Brougham's essay, for a recognition of the existence of irregularities in the cells, but have found none, except of such as are of microscopic size. "The lines," he says, "may not be exactly even which the bee forms; the surfaces may have inequalities to the bee's eye, though to our sight they seem plane; and the angles, instead of being pointed, may be blunt or roundish, but the proportions are the same: the equality of the sides is maintained, and the angles are of the same size, that is, the inclination of the planes is just. . . . . Now, then, the bee places a plane in such a position, whatever be the roughness of the surface, that its inclination to another plane is the true one required." §

Lord Brougham's answer to L'Houillier's criticisms may be cited to the same effect. When the latter speaks of the conditions re-

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Maraldi's measurements with theory could only arise from his assuming that the angle of inclination of the rhomboidal plane was the same with that of the hexagon, viz. 120°, from which, no doubt, it would follow that the angles of the rhombuses should be 109° 28′ and 70° 32′ respectively." — Lord Brougham, Nat. Theol., p. 351.

* Natural Theology, London, 1856, p. 224.

† Ibid., p. 197.

‡ Ibid., p. 324.

§ Ibid., p. 191.

quired being such as theory and observation "nearly agree" in giving to the cells, Lord Brougham replies: "The 'nearly' is quite incorrect: there is an absolute and perfect agreement between theory and observation." *

Mathematicians appear to be of one accord in this; viz. if economy of space and wax is sought, that the form of the cell should be the one alleged to have been ascertained by Maraldi, and which was really calculated by Koenig, and by hundreds of others since his time. Careful observations, however, tend to prove that such a cell is rarely, perhaps never, realized. For, while the deviations from the true form do not exceed a certain limit, a piece of comb, ten cells square, can hardly be found in which one or more irregularities do not occur, of such magnitude, that, however they may look to the bee's eye, can be readily detected by man's. The best observers, such as Reaumer, Hunter, the Hubers, and others, have noticed some of these, but as their investigations had for their chief object the clearing up of other points relating to the habits of the bee, the irregularities of the cells were passed by, for the most part, with merely a mention.

Worker Cells. — These will be treated of first, because they are the most numerous. The drones of a hive only amount at the most to a few hundreds, while the workers are estimated at many thousands, and the number of cells is proportional to the number of young reared. All the varieties found in the worker are repeated in the drone and honey cells, though in the last-mentioned kind the variations are the most marked, and some are introduced which are not found in either of the others.

The average *diameter* of a worker cell, measured on a line perpendicular to its sides, as deduced from the following table, is 0.201, or one fifth of an inch, but it may be increased or diminished in different parts of the same comb.† Reaumer expresses his belief that this was the case, but he gives no measurements. The table given below is the result of the examination of four pieces of comb, which were in all re-

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* *Op. cit.*, p. 350.

† Reaumer found that twenty worker cells measured four inches less half of a line; "neglecting the half of a line, the diameter of a single cell would be 2.4 lines" (French); and Huber gives the same dimensions, as also Kirby and Spence, who quote their description of everything relating to the bee from Reaumer and Huber. Latreille found that 76 millimeters comprised 14 cells, when measured in one direction, and 14.5 in another.

spects good average specimens. First, a line of ten cells,* arranged in the direction of the diameter, perpendicular to one of the sides, and then two other sets of the same number, similarly arranged in the direction of the other two diameters, and crossing the first, were carefully measured. Three series of such measurements were made from different parts of each comb. The columns marked I., II., III. give the measurements in the direction of the three diameters.

Combs.		I.	II.	III.	Greatest Difference.
		Inch.	Inch.	Inch.	Inch.
A Series,	1	2.04	1.95	1.98	0.09
	2	2.04	1.93	1.95	0.11
	3	2.10	2.02	1.92	0.18
B Series,	1	2.00	2.03	2.05	0.05
	2	1.98	2.02	2.05	0.07
	3	2.04	2.05	2.05	0.01
C Series,	1	2.05	2.05	1.98	0.07
	2	2.08	2.08	1.98	0.10
	3	2.09	2.08	1.98	0.11
D Series,	1	1.93	1.97	1.95	0.04
	2	1.97	2.06	1.85	0.21
	3	2.00	1.99	2.10	0.11

The greatest aggregate diameter of any one series of ten cells was 2.10 inches, and the least 1.85 inches, making a difference of 0.25 inch, or the diameter of a cell and a quarter. The average difference is, however, a little less than 0.10 inch. These irregularities do not accumulate beyond a certain amount, and those of one portion are often counteracted in another portion of the same row. In a large piece of comb, sixty cells occupied the space of one foot, which would make the diameter of a cell equal to 0.20 inch; nevertheless, ten cells taken from either end, and ten taken from the middle of this same comb, when compared, gave marked differences. This correction is not, however, a constant condition, for we have, perhaps in most instances, found Hunter's statement correct, viz. that the cells gradually increase in size, the last formed being the largest.†

* Ten cells were measured, in order to avoid the accumulating error resulting from the measurement of a series of single cells. The error in the measurement of ten cells is no greater than that of measuring one, and divided among the ten becomes inappreciable.

† Works of John Hunter, Palmer's edition, Vol. IV. p. 436.

It may be asked, if the comb was not built with all its diameters equal, but afterwards accidentally disturbed. The comb is suspended mostly from the uppermost portion, the lowermost hanging free until considerable progress is made, when it is more or less attached by the sides; taking into consideration the material of it, and the weight, when filled with honey, or covered with crowds of bees, it seems quite probable that in a hot day the softened wax would be stretched by its own weight, thus making the transverse diameter of the cells shorter, and the others proportionally longer. To test this, cells from six different pieces of comb were measured in the direction of their three diameters; the result was, that the aggregate transverse diameters of 570 cells was 38.94 inches, and that of the other two was 38.84 and 38.90 inches respectively. The transverse diameter, the one liable to be shortened, was absolutely a little the longest.

A variation in the diameters does not necessarily bring with it an inequality in the breadth of the sides, or a difference in the angles. If, however, one of the sides is wider or narrower than the others, which it often is, the angle which it makes with the adjoining ones must be greater or less than 120°, the normal angle. In order to be able to measure the sides as accurately as possible, cross sections were made midway between the mouth and base of the cell, where they are thinnest and the angles sharpest. These sections were obtained by filling the cells with plaster of Paris, and after this had hardened, cutting them down to the required point. In this way, all distortion was prevented. The following table gives the result of the measurement of the different sides of a series of twelve cells.

Sides.	CELLS.											
	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1	0.14	0.14	0.14	0.13	0.11	0.10	0.12	0.07	0.14	0.00	0.13	0.10
2	0.12	0.12	0.14	0.11	0.13	0.14	0.14	0.15	0.13	0.14	0.15	0.14
3	0.15	0.12	0.11	0.14	0.13	0.14	0.13	0.15	0.09	0.14	0.13	0.14
4	0.11	0.13	0.14	0.10	0.11	0.11	0.12	0.11	0.14	0.10	0.13	0.12
5	0.13	0.12	0.14	0.12	0.13	0.12	0.14	0.11	0.10	0.14	0.09	0.13
6	0.14	0.13	0.12	0.14	0.13	0.11	0.14	0.14	0.09	0.14	0.10	0.15

Smallest side in 72 cells, 0.070 inch.
Average " " " " 0.125 "
Longest " " " " 0.150 "

Of all the parts of the cell there is none where the variation is more striking than in the *rhombic faces* of the base. This fact is the more noteworthy, since it is upon these, and the angles they make with each other and the sides, that rests the nicest part of the problem relating to the adaptation of the cell to the contained bee. The relative size of the faces may be so changed that two of them make nearly the whole of the base, while the third almost vanishes, or one of the faces may have any size between this extreme and the normal one.

The fourth face, which has been so often noticed, has generally been spoken of as belonging more especially to those cells which are intermediate between the cells of drones and workers. Although it occurs in these, we have found it quite common in the middle of pieces of comb consisting solely of either worker, drone, or honey cells.* In one piece of worker comb containing about five hundred cells, nearly all had a fourth face.

The causes which lead to the introduction of the fourth face are chiefly two, irregularity in the size of the cells and incorrect alignment of them on the two sides of the comb. Each cell on one side of the comb being normally in contact, by its rhombic faces, with three cells on the other, and these fitting exactly, if a cell is increased, it will project beyond them, and thus come in contact with a fourth, and a new face will be formed. We have seen this happen in a single cell, but very commonly a row of cells increases for four or five cells, and gradually diminishes again to the ordinary size. With this increase and decrease of the cell, the fourth face comes and goes.

Incorrect alignment is the more common cause.† If a given row of

* These were studied either after cutting away the body of the cells, leaving only the basal plate which separates those of opposite sides, or by means of casts obtained by filling the cells with plaster of Paris. After this last has dried, if the mass is heated, the wax is absorbed by the plaster, when the casts of the two sets of cells separate. In old brood-combs, where many successive cocoons have been spun, these form a thick and resisting cast of the base of the cell and may be extracted, giving its precise form. In some instances, fourteen distinct layers of cocoons were counted, showing the number of broods which had occupied the cells.

† This introduction of the fourth face to the basal pyramid, through incorrect alignment, was thoroughly investigated several years since by Mr. Chauncey Wright, of the Nautical Almanac Office, and who, at the same time, constructed models illustrating his views. These models are deposited in the Museum of Comparative Anatomy and Physiology at Cambridge. For a discussion of various points connected with the geometry of the cell, see his article, entitled *The Economy and Symmetry of the Honey-Bee's Cell*, in the Mathematical Monthly for June, 1860.

cells on one side of the comb ceases to be parallel with those on the other, with which it was connected when the comb was begun, and diverges from them, it is gradually transferred to a new series; as the cells come in contact with those of the new series, the fourth side appears, and, at the same time, one of the original sides, viz. that directly opposite to it, is gradually diminished, and may vanish. This divergence is, however, sometimes insufficient to make the separation of the rows complete, and may gradually diminish again, as they are extended by the construction of new cells, so as to bring them back to the original position, when the irregularity is corrected.

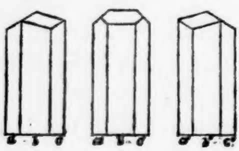
If, however, the separation of the two rows at length becomes complete, so that one of the faces is lost and a new one formed, all the basal portion of the cell becomes reversed, as will be seen by reference to Figs. 1 and 2; the first representing the cells when the base is viewed, and the second when looked at perpendicularly to one of the sides. In both figures *A* indicates the ordinary form of the cell. The whole series of Fig. 1 shows the gradual introduction of the new face, which is seen on the lower border, and the elimination of one of the original faces, which is seen on the upper border. At *B*, which is intermediate between the two extremes, the four faces consist of two equal rhombs, — one of which is the outgoing and the other the incoming one, — and two equal hexagons. *B*, Fig. 2, represents the sides of the same cell, which, instead of forming three trapeziums, as at *A*, *a*, *b*, *c*, now form two pentagons, *a′* and *c′*, and a parallelogram, *b′*. At *C*, Figs. 1 and 2, the forms are in all respects the reverse of those of *A*. *A* and *C* are symmetrical with each other, and *B* is symmetrical in itself. No precise number of cells is necessary for the purpose of making this transition, for it may take place in two or three, or extend through a long series, as in Fig. 1.

Fig. 1.

A *B* *C*

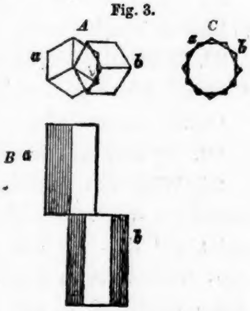
Fig. 2.

A *B* *C*



There is another variation which we have noticed twice, — once in drone, and once in worker comb, involving a large number of cells. If a piece of normal comb be held in the position in which it was built,

Fig. 3.



two of the opposite angles of the hexagon, Fig. 3, *A*, *a*, will be in the same vertical line, and two of the sides will be parallel to this. The same is true of the opposite side of the comb; and thus all the corresponding parts of the cells on the two sides will be parallel. In the deviation we are now noticing, the change is like that represented in *A*, where the cell *a* is in its true position, while the cell *b*, which is from the opposite side, and is in contact with *a*, varies from it by about 30°. If we look at these two cells in the direction of their sides as at *B*, the prism *a* will have one of its angles towards the eye, and *b* one of its sides. If rows of cells are constructed on each of the sides *a* and *b*, Fig. 3, *B*, it will be seen that the rows thus formed on the two faces of the comb will cross each other continually. A modification of this variety is seen at *C*, where the axes of the two adjoining prisms, instead of being separated as usual by the semidiameter of a cell, coincide; consequently, as the apices of the angles of *a* project beyond the sides of *b*, *a* will not only be in contact with *b*, but by its angles with the six cells by which *b* is surrounded. In either of these cases the pyramidal base becomes impracticable, and the flat bottom of the cell is substituted for it almost as a matter of necessity. The bottoms of the cells being flat, it is obvious that the change of position by rotation of the cell on its axis may be carried to any extent, without leading to an interference with the cells of the opposite side; in fact several degrees of it have been observed.

Since the mouths of such cells are in the same plane with those normally constructed in the same comb, and since the pyramidal base is cut off, they are shortened by an amount equal to the height of that of the base, and therefore are of a proportionately less capacity than the normal cell. Nevertheless, such truncated cells are used for rearing the young, and, like the others, were found to contain cocoons.

In curved or bent combs the cells on the concave side tend to become narrower, while those on the other tend to become broader towards their mouths. The bees meet this emergency in one of the following ways: —

On the convex side, —

1st. By allowing the cavity of this cell to become broader, without any correction being made.

2d. By thickening the walls of the cell in proportion to its tendency to become broader, and thus keeping the diameter of its cavity uniform.

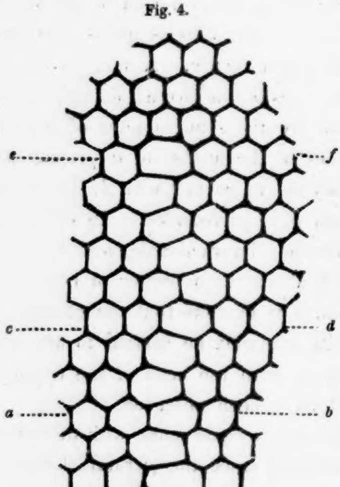
3d. When the divergence reaches a certain amount, by making a false-cell, with a pointed bottom, between the diverging cells.

On the concave side, —

1st. By narrowing the cell towards its mouth.

2d. When two adjoining cells converge so much as to render the mouth too small, the walls between them are suppressed at a certain point, and thus the two mouths are merged, and the compound cell thus formed has a double base, and but one entrance, the two cells being combined, as are certain kinds of twin crystals, or of double monsters. The form of the mouth under these circumstances is, however, liable to a considerable range of variation, as in the central line of cells in Fig. 4,* in which are a variety of hexagons. That on the line *a*, *b* has three sides at one end, united by two long sides with one at the other, and thus two of the opposite sides are not parallel; at *c*, *d*, two sides at either end are united by two long sides, these last being parallel; and at *e*, *f*, the mouth of the compound cell has seven sides. Each has a partition at its base, separating the two originally distinct cells, and each was lined with a cocoon, showing that it had been used for rearing young.

Fig. 4.



In combining the mouths of two adjoining cells, it will be seen that this does not consist merely in suppressing the partition between them; for if this were so, each of the long sides would contain more or less of an angle, as at the lower side of *g*, according to the degree of convergence, until three of the sides of each of the combining cells had disappeared. Instead of this, the portions of two sides forming the angle just referred to are replaced by one straight side, as on the upper side of *g*, and in both of the long sides of the undulating line of cells above it.

* Figs. 4, 5, and 6 are made from impressions obtained directly from the comb and transferred to wood. They represent the forms of the cells exactly.

Drone Cells. — These are liable to substantially the same variations as the worker cells. Reaumer observed that they were larger by one ninth in one diameter than in another.* Four pieces of drone comb gave the following measurements.

Combs.		I.	II.	III.	Greatest Difference.
		Inch.	Inch.	Inch.	Inch.
A Series,	1	2.63	2.72	2.67	0.09
	2	2.70	2.60	2.72	0.12
	3	2.80	2.58	2.60	0.20
B Series,	1	2,47	2.70	2.54	0.23
	2	2.54	2.50	2.55	0.05
	3	2.56	2.58	2.37	0.21
C Series,	1	2.54	2.55	2.47	0.08
	2	2.59	2.50	2.55	0.09
	3	2.64	2.61	2.68	0.07
D Series,	1	2.40	2.47	2.46	0.07
	2	2.45	2.43	2.36	0.09
	3	2.67	2.52	2.49	0.18

I., II., III., in the above table, indicate the diameters drawn perpendicularly to the three pairs of sides of the hexagons, and series 1, 2, 3 indicate measurements of cells made from three portions of each comb. Ten cells were measured in each case.

In comparing all of the above measurements, it is found that the smallest aggregate diameter of any ten cells is 2.36 inches, and the largest, 2.80 inches, making an extreme difference of 0.44 inch, or the diameter of a drone and almost that of a worker cell in addition. The greatest variation in any one series was 0.21, or a little more than four fifths of the diameter of a drone cell, which is somewhat less than the quantity given by Reaumer.

The following measurements from twelve consecutive rows of cells, of ten each, from the middle of a piece of drone comb, show the progressive variation from one row to another.

1st row	2.47 inches.	7th row	2.64 inches.
2d "	2.50 "	8th "	2.67 "
3d "	2.51 "	9th "	2.67 "
4th "	2.54 "	10th "	2.66 "
5th "	2.58 "	11th "	2.63 "
6th "	2.62 "	12th "	2.65 "

* *Op. cit.*, Tom. V. p. 398.

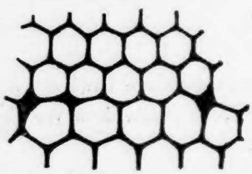
Transition Cells. — As drone are one fifth larger than worker cells, and as both are combined in one and the same piece of comb, a transition cannot be made from one to the other without some disturbance in the regularity of the structure. It would be a nice problem to determine the way in which this could be effected with the greatest economy of space and material. The bees do not appear to have any systematic method of making such a change. More commonly, they effect it by a gradual alteration of the diameters, thus enlarging a worker into a drone, or narrowing a drone into a worker cell. This alteration is usually made in from four to six rows. The following table gives an illustration of the rate of alteration in such a case, beginning with four drone cells of the usual size, and ending with four worker cells.

Four drone cells measured in the

1st row	1.02	inch.
2d "	0.97	"
3d "	0.95	"
4th "	0.86	"
5th "	0.83	"
6th "	0.80	"

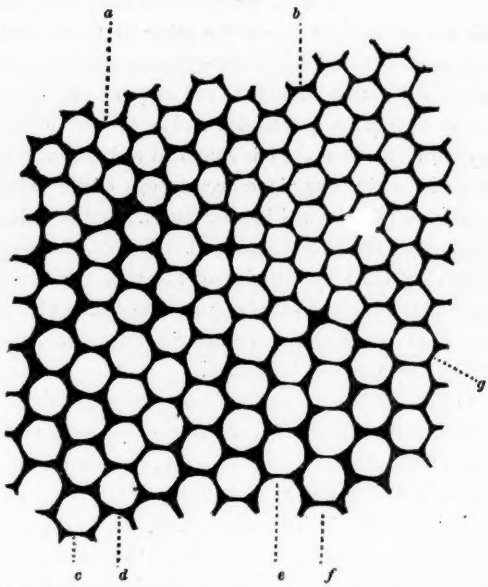
This last measurement exactly equals that of four worker cells. The rate of the reduction of the size of the cell is not uniform, the differences between successive rows being .05, .02, .01, .03, .03 inch. We have, however, seen the transition made with two rows of transitional cells, and as in Fig. 5, with only one. In this last case, the regularity of two adjoining rows is sacrificed.

Fig. 5.



In consequence of the gradual narrowing or widening of the transition cells, the comb tends to become more or less triangular and the cells to become disturbed. The bees counteract this tendency by the occasional intercalation of an additional row, of which two instances are given in Fig. 6, at *a* and *b*, where three rows of worker cells are continuous with two of drone cells, *c d* and *e f;* or, reversing the statement, and supposing the transition, as in the building of the comb, is from worker to drone cells, a row of the latter is from time to time omitted as the rows *a* and *b;* in this way,

Fig. 6.



the regularity of the comb is preserved.* This, however, is not done at definite intervals; for in one piece of comb two intercalated series were nine cells apart, in another, six, and in another, four.

Mr. Langstroth has given a good figure, illustrating the form of the mouths of some of the cells where the worker and drone cells come together.†

The presence of a fourth face in the base of the transitional cells is by no means constant, as asserted by several observers, for we have seen the change from worker to drone cells without the fourth face appearing in any of them.

In all the transitional cells of brood-comb cocoons are invariably found, showing that they have been occupied. It is obvious that some of these would be either too large for a worker or too small for a

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* This figure was made from a piece of old brood-comb, in which the lip of the drone cells was very much thickened, and the mouths were almost circular. There is nothing abnormal in this, except at those points where the row of intercalated cells, as *a* and *b*, connect with the drone cells.

† Treatise on the Bee, p. 74 and Pl. XV.

drone. It would, therefore, be of considerable interest to know whether such cells are occupied by one or the other of these kinds of bees. The determination of this point is important on another account. Siebold has ascertained that drones do not require impregnation, while the workers as well as the queens do; and as the act of impregnation is voluntary with the queen, she is supposed to have some guide to inform her whether a given egg is to become one or the other kind, for she never makes a mistake and impregnates an egg in a drone cell, or omits to impregnate one in a worker cell. Siebold, therefore, supposes that the queen is guided by the size of the mouth of the cell, and if the abdomen touches one kind, impregnation takes place, and if the other, not. The transitional cells being intermediate, would not by their size give her the usual indication.

Honey Cells. — When the stock of honey becomes greater than the ordinary brood cells will contain, the bees either enlarge these, or add to them other cells often of larger capacity, or construct a new comb, devoted entirely to the storing of honey. While the cells of this last are built unequivocally in accordance with the hexagonal type, they exhibit a range of variation from it which almost defies description. Of all who have written on the subject, Mr. Langstroth is the only one we have met with who seems to have particularly mentioned their irregularity, which he does in the following words: "Those [cells] in which the honey is stored vary greatly in depth, while in diameter they are of all sizes, from that of a worker to that of drone cells." * We have found them even 2.10 inches in depth, or four times that of a worker cell; sometimes they are square or pentagonal; their alignment is rarely if ever exact, so that the presence of a fourth face is more common than with the other kinds. The basal pyramid changes constantly; the cast of a piece of comb, containing over four hundred cells, showed but few in which there was not some irregularity obvious to the eye; either the faces were unequal, or there was a fourth, and even a fifth face, or the pyramid was too high or too low, or suppressed, or the body of the cell was not equilateral, or its angles too large or too small. The normal angle which one side makes with its adjoining ones is 120°; the following measurements, taken from casts of average specimens, exhibit a degree of variation by no means unusual.

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* On the Honey-Bee, p. 74. New York, 1859.

Angles.	CELLS.			
	I.	II.	III.	IV.
1	117°	117°	112°	113°
2	122	124	127	130
3	121	116	120	122
4	110	119	114	110
5	135	125	125	126
6	115	118	121	117

Largest angle,	135°.0
Average of the 24 angles,	119°.5
Smallest,	110°.0

The above measurements were made with an accurate goniometer; those of cells I. and II. by Professor Cooke, and of III. and IV. by the author, and each is the average of three; but, in nearly every case, there is an error of from one to three degrees, which is inseparable from the measurement of surfaces and angles which are not exact.

When honey cells are built on a curved dividing wall, the bees seem to make no attempt to correct the effect of the converging and diverging lines. In the brood-combs they usually make an attempt, at least, to keep the cavity of the cells of the usual shape; but in the honey-comb we have seen the mouths of the cell in one diameter expanded to double their usual size. The most of the irregularities seem to have no obvious cause, but all looks as if the bees, aware that close conformity to the type-form was unnecessary for the mere storing of honey, became careless in executing their work.

The distribution of the wax in the sides and angles of the cells, as seen in the sections, appears to the naked eye quite regular; but, with the aid of a low power, is often quite the reverse. One can easily detect an inequality in the thickness of the walls, — two different walls of the same cell, or two parts of one and the same wall being not unfrequently the one double the thickness of the other. The excavation of the angles, though sometimes wonderfully exact, is frequently done in such a way that the apices of opposite angles do not correspond. This is equally true of all of the three kinds of cells. In the cells, and still better in the casts of them, one can easily observe the fact that the edges of the sides are never exactly planes, and that consequently the line of union of two adjoining sides is somewhat undulating.

The statements made in the foregoing pages tend to show that the

cell of the bee has not the strict conformity to geometrical accuracy so often claimed for it, but, as the best observers have maintained, is liable to marked variations, chief among which the following may be mentioned.

1st. The diameters of worker cells may so vary, that ten of them may have an aggregate deviation from the normal quantity, equal to the diameter of a cell. The average variation is a little less than one half that amount, viz. nearly 0.10 inch, in the same number of cells.

2d. The width of the sides varies, and this generally involves a variation of the angles which adjoining sides make with each other, since the sides vary not only in length, but in direction.

3d. The variation in the diameters does not depend upon accidental distortion, but upon the manner in which the cell was built.

4th. The relative size of the rhombic faces of the pyramidal base is liable to frequent variation, and this where the cells are not transitional from one kind to another.

5th. When a fourth side exists in the basal pyramid, it may be in consequence of irregularity in the size of the cells, or of incorrect alignment of them on the two sides of the comb.

6th. Ordinarily, the error of alignment does not amount to more than one or two diameters of a cell. But occasionally the rows of cells on one side of the comb may deviate from their true direction with regard to those on the other, to the extent of 30°. In consequence of this deviation and the continual crossing of the rows on opposite sides, the pyramidal base is not made, and the cell is thereby shortened.

7th. When a piece of comb is strongly curved, or two portions form an angle with each other, there is no constant way in which the tendency to the distortion of the cells is met; consequently the cells found at the curves or angles have a variety of patterns.

8th. Deformed worker and drone cells are used for rearing the young.

All of these variations are found in the three different kinds of cells, but are much more frequent and marked in the honey than in either worker or drone cells. In view of the frequency of such, however near the bee may come to a typical cell in the construction of its comb, it may be reasonably doubted whether a type cell is ever made. Here, as is so often the case elsewhere in nature, the type-form is an ideal one, and, with this, real forms seldom or never coincide. Even in crys-

tallography, where the forms are essentially geometrical, we are told that "natural crystals are always more or less distorted or imperfect," and that "the science of crystallography could never have been developed from observation alone"; * i. e. without recourse to ideal conceptions. An assertion, like that of Lord Brougham, that there is in the cell of the bee "perfect agreement" between theory and observation, in view of the analogies of nature, is far more likely to be wrong than right; and his assertion in the case before us is certainly wrong. Much error would have been avoided, if those who have discussed the structure of the bee's cell had adopted the plan followed by Mr. Darwin, and studied the habits of the cell-making insects comparatively, beginning with the cells of the humble-bee, following with those of the wasps and hornets, then with those of the Mexican bees (*Melipona*), and, finally, with those of the common hive-bee. In this way, while they would have found that there is a constant approach to the perfect form, they would at the same time have been prepared for the fact, that even in the cell of the hive-bee perfection is not reached. The isolated study of anything in natural history is a fruitful source of error.

Since bees give so much variety to the forms of their cells, and can adapt them to peculiar circumstances, some of which do not occur in nature, as, for example, in Huber's experiment with the glass surface, which last they so persistently avoided, and in view of the fact, too, that in meeting a given emergency they do not always adopt the same method, one is driven to the conclusion that the instinct of one and the same species either is not uniform in its action and is quite adaptive in its quality, or to admit, with Reaumer, that bees work with a certain degree of intelligence.

Five hundred and sixty-first Meeting.

January 31, 1866. — STATUTE MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary read letters from Prof. Tayler Lewis, Mr. L. M. Rutherfurd, Dr. J. W. Draper, Mr. G. W. Hill, and M. Chasles, in acknowledgment of their election into the Academy.

The President read a letter from Mr. Richard Greenough, presenting to the Academy a bust of Sir Charles Lyell.

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* Professor Cooke, Religion and Chemistry, p. 287.

In acknowledgment of this gift, it was *voted*, That the thanks of the Academy be presented to Mr. Greenough for his very valuable and acceptable present.

The report of the Rumford Committee, referred to this meeting, was taken up, and, in accordance with its recommendation, it was *voted*, That the Rumford Committee may receive from Mr. O. N. Rood the results of his investigations on "Photometry," instead of those on "the Physical Relations of the Iodized Plate to Light," for which an appropriation from the Rumford fund was made at the meeting of September, 1863.

The following gentlemen were elected members of the Academy: —

Hon. Erastus B. Bigelow, of Boston, to be Resident Fellow in Class III., Section 3.

Mr. Henry Mitchell, of Lynn, to be Resident Fellow, in Class I., Section 2.

Rev. Barnas Sears, President of Brown University, to be Associate Fellow, in Class III., Section 2.

Prof. Asahel C. Kendrick, of Rochester, N. Y., to be Associate Fellow, in Class III., Section 2.

Mr. Arthur Cayley, of London, to be Foreign Honorary Member, in Class I., Section 1, in place of the late Sir William Rowan Hamilton.

M. Delauney, of Paris, to be Foreign Honorary Member, in Class I., Section 1, in place of the late Sir J. W. Lubbock.

Dr. Joseph Dalton Hooker to be Foreign Honorary Member, in Class II., Section 2, in place of the late Sir William Jackson Hooker.

Mr. C. M. Warren presented the following communication: —

On a New Process of Organic Elementary Analysis for Substances containing Chlorine. By C. M. Warren.

Organic bodies containing chlorine — and probably those also, that contain bromine and iodine — may be analyzed by a process analogous

to that which I have already described for substances containing sulphur.*

As in that process, so also in this, the substance is burnt in a stream of oxygen gas, in the manner described in my first paper, on Organic Elementary Analysis.†

Similarly, also, as in the analysis of sulphur compounds, the chlorine is absorbed and retained during the combustion, by a suitable substance placed in the anterior end of the combustion tube; this substance being subsequently removed, and the chlorine determined therefrom in the usual manner. The carbon and hydrogen, in either process, are determined from the same portion of the substance as the sulphur or chlorine, in a manner similar in other respects to that described for simple hydrocarbons. ‡

In pursuing this research some difficulty was experienced, as was anticipated, in finding a substance which would absorb and retain the whole of the chlorine, under conditions that would at the same time insure that every trace of the carbonic acid and water should pass through unabsorbed.

The search for this substance was confined to the oxides of the heavy metals, as these alone, from their strong affinity for chlorine, and weak affinity for carbonic acid, seemed to give encouragement of success.

The difficulty, however, in finding such a substance was chiefly due to the circumstance that most of the chlorides of these metals are either too volatile, or begin to suffer decomposition at too low a temperature; it being requisite that the absorbing substance, and the newly formed chloride of the same, should bear to be heated sufficiently to prevent both condensation of water and absorption of carbonic acid, and at the same time avoid a temperature high enough to occasion any appreciable decomposition of the chlorid.

This question of temperature became, therefore, a prominent one in the investigation, as evidently the success of the process must depend, in a great degree, on the proper management of the temperature of the absorbing substance, within such limits as might be found to give satisfactory results. Hence, my first step was to devise means to se-

* Proceedings of the American Academy, March, 1865; American Journal of Science and Arts, 1866, XLI. 40.

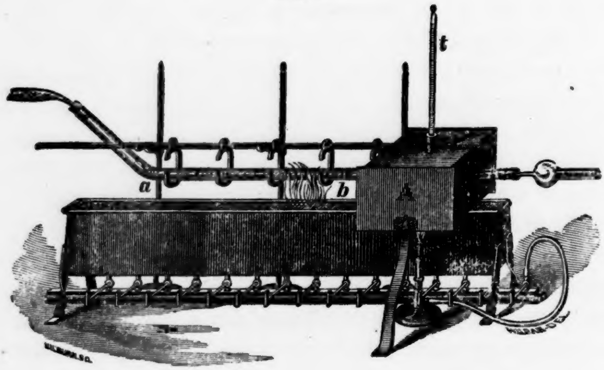
† Proceedings of the American Academy, 1864, p. 251; American Journal of Science and Arts, 1864, XXXVIII. 387.

‡ *Loc. cit.*

cure the necessary control of the temperature of that part of the combustion tube which should contain this substance.

For this purpose was constructed a sheet-iron air-bath or chamber, A, Fig. 1, provided with two holes — one in each side — to receive

Fig. 1.



the combustion tube, and a tubulure in the top for a thermometer. One end of the air-bath is made to rest on the combustion furnace, and the other, which projects a few inches from the front of the furnace to make room for a lamp, is supported by a leg resting upon the table. The bulb of the thermometer is placed in a central position, in the interior of the bath, close by the side of the combustion tube.

The temperature of the air-bath, and consequently of the substance contained in the combustion tube within, is easily regulated by means of a Bunsen's burner placed under the front end of the bath, as shown in Fig. 1. With the exception of the air-bath, the apparatus employed is the same as that used in the analysis of substances containing sulphur, a full description of which is given in the papers above referred to.

The substance that I have found best adapted to absorb the chlorine, for substances easily combustible, is brown oxide of copper, prepared by precipitation with potassa and ignition over a gas flame.

Difficultly combustible substances, like chloroform, are not completely burnt in oxygen in contact with asbestos alone, but require the presence of a body having affinity for chlorine; otherwise there is formed a liquid body, difficultly volatile, — probably a chloride of carbon, — which condenses in the vacant part of the tube, from *b* to *c*, Fig. 2,

and which cannot be entirely burnt off and save the analysis. In such cases the absorbing substance is mixed with the asbestos occupying the back part of the tube, where the combustion takes place. It is evident that oxide of copper would not answer for this purpose, as at so high a temperature dichloride of copper would be formed, which, being insoluble in dilute acids, would interfere with the determination of the chlorine. Oxide of zinc has been found to give good results with such substances.

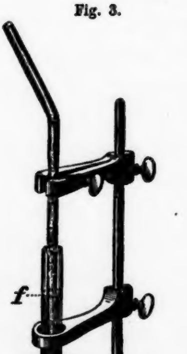
The preparation of the combustion tube, and the arrangement of the mixture of asbestos and the absorbing substance, is the same — except in the case last mentioned — as in the analysis of substances containing sulphur, as shown in Fig. 2, viz. the space between *a* and *b*, about 10 inches in length, is packed with pure asbestos; between *b* and *c*, — a space of about two inches, — being left vacant, a plug of asbestos is placed at *c*; the space between *c* and *d*, 4 to 5 inches in length, is filled with an intimate mixture of asbestos and brown oxide of copper; and, finally, a plug of asbestos is placed at *d*.

Fig. 2.

After the combustion, the chloride, together with the excess of oxide, is extracted from the asbestos by means of dilute nitric acid.

To facilitate the removal of what may adhere to the sides of the tube, the apparatus shown in Fig. 3 will be found serviceable, as in the analysis of sulphur compounds.

Fig. 3.



I. *Experiments with Oxide of Lead and with Oxide of Copper, placed in the anterior end of the combustion tube, as absorbents of Chlorine in the analysis of substances difficultly combustible.*

The substance selected for analysis, as a test of the process for that class of bodies which are difficultly combustible, containing but a small percentage of hydrogen, was commercial chloroform. The preparation employed was first subjected to redistillation.

Its boiling-point was found to agree essentially with that assigned to pure chloroform in Gerhardt's *Traité de Chimie*. When the usual tests were applied, no impurity could be detected.

Experiment 1. — A mixture of oxide of lead and asbestos was placed in the anterior end of the combustion tube, between *c* and *d*, Fig. 2, as previously described. As chloride of lead was supposed to bear a pretty high temperature, without volatilization or decomposition, the use of the air-bath was omitted in this experiment, and the oxide gently heated with a small flame from the combustion furnace. The combustion had not proceeded far, when it became apparent, from deposition of minute drops of liquid on the sides of the vacant part of the tube, — from *b* to *c*, Fig. 2, — that the combustion of the chloroform was incomplete, although no doubt could exist as to the presence of an excess of oxygen. This deposit of liquid, which, as already stated, was supposed to be a chloride of carbon, was found to be difficultly volatile, suffering partial decomposition, and leaving on the tube a brown deposit, which was not entirely removed by ignition in a stream of oxygen. The high temperature employed to burn off this deposit occasioned excessive heating of the posterior end of the mixture of lead oxide and asbestos; and this may have been the cause, to some extent, of the excess in the determinations of carbon and hydrogen, although subsequent analyses indicate that the sample of chloroform under examination contained a larger percentage of these elements — particularly of the latter — than belongs to pure chloroform. This experiment gave 11.47 per cent of carbon, and 1.87 per cent of hydrogen. Theory gives 10.07 per cent of carbon, and 0.85 per cent of hydrogen. The mixture of asbestos and oxide and chloride of lead was removed from the tube, and treated in the usual manner with a solution of bicarbonate of soda to obtain a soluble chloride. This operation was found extremely tedious. Even after treatment for more than two weeks, with occasional fresh portions of the bicarbonate and frequent agitation, the decomposition of the lead chloride was still found to be incomplete, and the operation was abandoned. As this is given in the text-books as a good process for the separation of chlorine from chloride of lead,* I am led to presume that in this case the excess of heat employed gave rise to the formation of an oxychloride, which is, doubtless, more slowly acted upon by the bicarbonate. This single

* H. Rose, Chimie Analytique, new French edition, p. 801.

experiment does not, therefore, prove that oxide of lead may not be employed in this process with good results, when used for easily combustible substances, and excessive heat is avoided. But it will, unquestionably, be found preferable to use a substance which will give *directly* a soluble chloride.

Experiment 2. — This experiment was conducted as the last, with only this difference, viz. that oxide of copper was substituted for the oxide of lead. No better results, however, were obtained. The reappearance of the difficultly volatile liquid in the vacant part of the tube, while there was assurance of there being no deficiency in the supply of oxygen, served to confirm the impression gained by the preceding experiment, — that chloroform could not be completely burnt in oxygen alone, but that a substance having affinity for chlorine would have to be mixed with the asbestos, at the point where the combustion takes place.

II. *Experiments with Oxide of Zinc, mixed with the asbestos in the posterior part of the combustion tube, as absorbent of Chlorine in the analysis of substances difficultly combustible.*

As already indicated, the chief object of this set of experiments was to determine whether the presence, at the point where combustion takes place, of an oxide capable of combining with the chlorine would have the effect to prevent the formation of the difficultly volatile liquid above mentioned, and thus remedy that defect in the process.

Experiment 1. — In this experiment, three grammes of oxide of zinc were intimately mixed in a mortar with the quantity of asbestos necessary to fill the space between *a* and *b*, Fig. 2, and that part of the tube then packed with this mixture in the usual manner. A similar mixture composed of asbestos and only one gramme of oxide of zinc was placed between *c* and *d*. The space between *b* and *c* was still left vacant, in order to be able to observe the effect. On account of the volatility of the chloride of zinc, it was deemed advisable to retain the use of the air-bath to control the temperature of the anterior portion of the combustion tube, which, in this experiment, was not allowed to exceed 160° C. The result was, as anticipated, that no such condensation of liquid between *b* and *c* occurred. In order to gain from this experiment some idea of the degree of volatility of chloride of zinc under such circumstances, the two columns of asbestos were treated for

chlorine, separately. The solution obtained from the anterior column was found to contain but a trace of chlorine, giving only a milkiness with nitrate of silver; showing that the chloride of zinc does not travel far through a column of asbestos from the point where the flame plays directly on the tube.

Results of the Analysis.—0.2067 gramme of chloroform gave 0.0798 of carbonic acid, 0.0276 of water, and 0.7372 of chloride of silver.

		Calculated.		Found.
Carbon	C_2	12	10.0671	10.5273
Hydrogen	H	1	0.8473	1.4514
Chlorine	Cl_3	106.2	89.0856	88.0455
			100.	100.0242

Experiment 2.—In this experiment, the whole length of the combustion tube from *a* to *d* was packed with a mixture of asbestos and four grammes of oxide of zinc. The temperature of the anterior end of the combustion tube was regulated, as in the previous experiment, by means of the air-bath.

Results of the Analysis.—0.1339 gramme of chloroform gave 0.0506 of carbonic acid, 0.0156 of water, and 0.4768 of chloride of silver.

		Calculated.		Found.
Carbon	C_2	12	10.0671	10.3062
Hydrogen	H	1	0.8473	1.2733
Chlorine	Cl_3	106.2	89.0856	87.9014
			100.	99.4809

These two analyses, agreeing as they do so closely, indicate that the chloroform analyzed contained larger percentages of carbon and hydrogen,—especially of the latter,—and a correspondingly smaller percentage of chlorine than the theoretical quantities; occasioned, probably, by the presence of some impurity. This view is supported by calculations made on the assumption that the excess might have arisen from volatilization of chloride of zinc, or from incomplete absorption of the chlorine; which would make the chloroform contain from two to six per cent more than the theoretical quantity of chlorine. These results are regarded, therefore, as satisfactorily establishing the utility of this process in the analysis of chloroform. But the analysis of this

body, containing as it does eighty-nine per cent of chlorine, and only eighty-five hundredths of one per cent of hydrogen, must be considered as an extreme case, and does not prove the process a good one for other classes of substances.

The next step, therefore, was to determine whether the process would be equally efficient in the analysis of substances rich in hydrogen, the combustion of which would give rise to the formation of a large quantity of hydrochloric acid. The substance selected for analysis, to settle this question, was chloride of amyl.

III. *Experiments with Oxide of Zinc, as an absorbent of Chlorine in the analysis of substances rich in Hydrogen.*

In these experiments, the oxide of zinc was employed in the same manner as above described for the analysis of chloroform. The chloride of amyl, which was the subject of analysis, was prepared in the usual manner. Its boiling-point was 102°, 8 corrected.

The following results of two analyses with oxide of zinc indicate that this oxide combined with and retained some of the carbonic acid. This result was not anticipated, as in the analysis of chloroform the determination of carbon was uniformly slightly in excess.*

The Results of these two analyses are as follows: —

1. — 0.1922 gramme of chloride of amyl gave 0.3513 of carbonic acid, 0.1854 of water, and 0.2528 of chloride of silver.

* Since the above was written, I have observed, on reviewing my notes, — not only of experiments with oxide of zinc, but also with oxide of copper, — that in every analysis in which I made note of carbonization, or blackening of the asbestos in the combustion tube, — which may sometimes occur from too rapid distillation of the substance, or, what amounts to the same thing, a deficiency in the supply of oxygen, — there was a loss in the determination of the carbon, and generally, also, in that of the chlorine; while the hydrogen would agree pretty nearly with the theoretical quantity. I am, therefore, at the present writing, inclined to suspect that the carbonization may have had some connection with the deficiency in the carbon determinations in these instances, although the blackening would readily and completely disappear so soon as a sufficiency of oxygen was supplied. This momentary blackening of the asbestos occurred in both of the analyses of chloride of amyl with oxide of zinc, but, as already intimated, was not regarded at the time of serious consequence, as similar phenomena in the analysis of hydrocarbons by my process were generally attended with good results. It may, therefore, remain an open question, whether the oxide of zinc may not serve a good purpose in the analysis of substances of the class now under consideration.

		Calculated.		Found.
Carbon	C_{10}	60	56.3910	49.85
Hydrogen	H_{11}	11	10.3383	10.72
Chlorine	Cl	35.4	33.2707	32.47
			100.	93.04

2.—0.1657 gramme of chloride of amyl gave 0.3314 of carbonic acid and 0.1608 of water.

		Calculated.		Found.
Carbon	C_{10}	60	56.3910	54.56
Hydrogen	H_{11}	11	10.3383	10.74
Chlorine	Cl	35.4	33.2707	

IV. *Experiments with Oxide of Copper, as absorbent of Chlorine in the analysis of substances rich in Hydrogen.*

In these experiments, for the reason previously stated, the oxide of copper could only be placed in the anterior end of the combustion tube, where it might be maintained at a tolerably low temperature. After two or three experiments, — which were but partially successful, — it became apparent that the range of temperature within which oxide of copper could be made serviceable to absorb the chlorine was probably rather limited.

It was observed, for example, that at 150° to 160° even brown oxide of copper, which had been but gently ignited, would fail to absorb nearly all of the chlorine, and consequently the determination of the carbon, and sometimes that of the hydrogen, would be in excess. In one experiment, in which the oxide of copper was kept at about 153° C., its appearance had suffered no change, and it was found to contain only 8.29 per cent of chlorine, or only about one quarter of the theoretical quantity. When a sufficiently high temperature is employed, on the contrary, the posterior end of the column of oxide of copper and asbestos has the appearance of being entirely changed into yellow chloride of copper, the rest of the column remaining, for the most part, of its original dark color.

In another experiment, with the oxide of copper kept at a temperature of about 160°, only about fourteen per cent of chlorine was obtained.

In both of these experiments the carbon determination was considerably in excess, and in one of them the hydrogen also. The oxide of copper employed had been strongly ignited.

Before proceeding further with these somewhat random experiments, it was deemed advisable to *determine* the temperature at which chloride of copper begins to give off chlorine, in order to know how far it would be safe to raise the temperature of the air-bath in conducting an analysis. By making use of the air-bath to regulate the temperature of the chloride of copper, this determination was easily made. During the heating of the chloride, a current of air from the air-gasometer was admitted through the tube in which it was contained.

Observations. — At 243°, not a perceptible trace of chlorine was given off. After the lapse of fifteen minutes, at 250°, the nitrate of silver, into which the gas was conducted, was observed to be slightly milky; this may, therefore, be taken as about the temperature at which chloride of copper begins to suffer decomposition. At 267°, a solution of nitrate of silver was instantly precipitated.

Thinking that perhaps the small quantity of chlorine evolved under these circumstances might be taken up again and retained if oxide of copper were present, and possibly, also, that in that case a higher temperature might be safely employed, — to make the conditions of the experiment conform in this particular to those which exist in an analysis, all but one inch of the chloride of copper was removed from the tube, and in its place was put a mixture of asbestos and oxide of copper, occupying a space of four inehes in length, forward of the chloride. The experiment was then repeated. Prolonged heating in a current of air, and afterwards in oxygen, during which the thermometer rose to 350°, produced no reaction with nitrate of silver. From this it appears that the chlorine, which is given off below this temperature from chloride of copper, when this is mixed with oxide of copper, is absorbed and retained by the latter; hence, that so high a temperature as 350° may be safely employed for the air-bath in conducting an analysis by this process.

Analysis 1. — In this analysis the oxide of copper employed was prepared in the ordinary way and strongly ignited. The space in the tube occupied by the mixture of asbestos and oxide of copper was five inches in length, and contained just five grammes of the oxide. During the experiment, the temperature of the air-bath was maintained at about 350°. At the close of the combustion there was no appearance of chloride of copper, except in the first half-inch at the back end of the column of the mixture of oxide of copper and asbestos; showing that the temperature employed was favorable for rapid and complete absorption of the chlorine.

Results of the Analysis. — 0.1682 gramme of chloride of amyl gave 0.3486 of carbonic acid, 0.1633 of water, and 0.2233 of chloride of silver.

		Calculated.		Found.
Carbon	C_{10}	60	56.3910	56.522
Hydrogen	H_{11}	11	10.3383	10.761
Chlorine	Cl	35.4	33.2707	32.773
			100.	100.056

Analysis 2. — The oxide of copper employed was of the same preparation as that used in Analysis 1. The space occupied by the mixture of asbestos and oxide of copper was only 3½ inches in length, but contained the same quantity, viz. 5 grammes of the oxide of copper, as used in the previous analysis. The temperature of the air-bath ranged from 250° to 253°. At the close of the combustion, it was found that all but ¾ inch at the forward end of the column of mixed asbestos and oxide of copper had the appearance of containing chloride of copper. By comparison with the corresponding observation in Analysis 1, it will be seen that the appearance of the chloride extends over more than five times the space in this analysis as in the former, showing that with strongly ignited oxide of copper a temperature higher than 250°, even as high as 350°, is more favorable for the absorption of the chlorine. The following results of the analysis, however, are equally accurate with those of the preceding analysis.

0.1669 gramme of chloride of amyl gave 0.3457 of carbonic acid, 0.1612 of water, 0.2213 of chloride of silver.

		Calculated.		Found.
Carbon	C_{10}	60	56.3910	56.489
Hydrogen	H_{11}	11	10.3383	10.785
Chlorine	Cl	35.4	33.2707	32.732
			100.	100.006

Analysis 3. — Under the impression that an oxide of copper which had been less strongly ignited might be effectual to absorb the chlorine at a lower temperature, I employed in this and the two following analyses a preparation of brown oxide of copper, obtained by precipitation with potash and ignition over an ordinary gas flame. In this analysis the temperature of the air-bath ranged from 150° to 158°. The space occupied by the asbestos mixture was four inches in length,

and contained three grammes of the oxide. Although the results of the analysis indicate that the temperature of the air-bath was too low, they also show, by comparison with the results obtained in operating with strongly ignited oxide at about the same temperature of the air-bath (see p. 92), that the brown oxide is decidedly preferable in respect to the temperature required. This was also shown by the appearance of the oxide after combustion, — the newly formed chloride being confined, in the case of the brown oxide, to a much shorter space.

Results of the Analysis. — 0.1640 gramme of chloride of amyl gave 0.3504 of carbonic acid, 0.1562 of water, and 0.1884 of chloride of silver.

		Calculated.		Found.
Carbon	C_{10}	60	56.3910	58.268
Hydrogen	H_{11}	11	10.3383	10.582
Chlorine	Cl	35.4	33.2707	28.360
			100.	97.210

Analysis 4. — Used the same preparation of oxide of copper as in Analysis 3, viz. the brown oxide. Temperature of the air-bath reached 170°. Slight carbonization occurred just at the close of the combustion, from extending the heat backward too soon, under a wrong impression that the substance was all burnt. Were it not for this circumstance, it is believed that this would have been a good analysis, although the temperature of the air-bath was kept so low. That a higher temperature of the bath is desirable, however, is shown by the fact that the chloride of copper appeared diffused over a space of 2½ inches. The length of the column of mixed asbestos and oxide of copper was only four inches in this experiment, containing *but one gramme* of the oxide.

Results of the Analysis. — 0.1568 gramme of chloride of amyl gave 0.3195 of carbonic acid, and 0.1522 of water.

		Calculated.		Found.
Carbon	C_{10}	60	56.3910	55.574
Hydrogen	H_{11}	11	10.3383	10.784
Chlorine	Cl	35.4	33.2707	

Analysis 5. — The oxide of copper employed was of the same preparation as that of Analyses 3 and 4. The temperature of the air-bath, however, was considerably higher, ranging from 240° to 247°. The

mixture of asbestos and oxide of copper occupied a space of five inches in length, but contained only two grammes of the oxide. At the close of the combustion there was no appearance of chloride of copper, except at the back end of the column, a space $\frac{3}{4}$ of an inch in length.

Results of the Analysis. — 0.1631 gramme of chloride of amyl gave 0.3383 of carbonic acid, 0.1557 of water, and 0.2157 of chloride of silver.

		Calculated.		Found.
Carbon	C_{10}	60	56.3910	56.542
Hydrogen	H_{11}	11	10.3383	10.607
Chlorine	Cl	35.4	33.2707	32.649
			100.	99.798

It can hardly have escaped observation, that the quantity of oxide of copper or oxide of zinc required to absorb the chlorine by this process is extremely small, in consequence of its being uniformly diffused through a large mass of asbestos; hence it is obvious that but little of a solvent is needed to extract the chloride. In this respect the new process bears a striking contrast to the old one, which involves the use of a large quantity of lime, necessitating a corresponding quantity of acid, and introducing disagreeable manipulation, which tend to increase the liability to error.

I have not yet tried the process recently described by Carius,* as the difficulty which I had found in obtaining tubes that would bear the pressure incident to his process for the determination of sulphur gave no encouragement of better success in the use of his process for the determination of chlorine, which is performed in a similar manner, although more complicated.

The advantage which my process affords, of being able to determine the three elements carbon, hydrogen, and chlorine at a single combustion, without the introduction of any difficult or hazardous manipulation, induces the belief that it will be found preferable to any other that has been devised.

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* Annalen der Chimie und Pharmacie.

Five hundred and sixty-second Meeting.

February 13, 1866. — MONTHLY MEETING.

The VICE-PRESIDENT in the chair.

The Corresponding Secretary read letters relative to exchanges.

Professor Washburn read a paper on the nature of the testimony of experts in courts of law; and he suggested that a legislative remedy might be found for the abuses to which the employment of expert witnesses by the parties in a suit frequently leads. A discussion of the questions raised in this paper then followed, in which the following gentlemen took part: Dr. C. T. Jackson, Professor H. R. Storer, Professor C. W. Eliot, Professor Parsons, and Dr. J. Bigelow.

Five hundred and sixty-third Meeting.

March 6, 1866. — SPECIAL MEETING.

The PRESIDENT in the chair.

The President called the attention of the Academy to the recent decease of the Right Rev. John B. Fitzpatrick, of the Resident Fellows.

Professor Washburn gave a recapitulation of his paper, read at the previous meeting, on the testimony of experts.

A discussion of this subject then followed, in which Professor Parker, Judge Bigelow, Mr. G. B. Emerson, Professor Bowen, Dr. Jarvis, Professor H. R. Storer, and Dr. Pickering took part.

On the motion of Professor H. R. Storer it was *voted*, That a committee be appointed to consider and report upon the subject of this discussion.

Pending the appointment of this committee the meeting adjourned.

Five hundred and sixty-fourth Meeting.

March 13, 1866. — ADJOURNED STATUTE MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary read letters relative to the exchanges.

The President called the attention of the Academy to the recent decease of Mr. Jonathan P. Hall of Boston, of the Resident Fellows.

In accordance with the recommendation of the Finance Committee it was *voted*, That the additional sum of five hundred dollars be appropriated for paper and printing, to be expended by the Publication Committee during the current year.

A committee was appointed, in accordance with the vote of the previous meeting, to consider and report upon the subject of expert testimony in courts of law; viz. Chief Justice Bigelow, Professor Washburn, Professor H. R. Storer, Dr. Tyler, Professor Rogers, Professor Horsford, and Professor J. Wyman.

Five hundred and sixty-fifth Meeting.

April 10, 1866. — MONTHLY MEETING.

The PRESIDENT in the chair.

The President called the attention of the Academy to the recent decease of Dr. Jared Sparks, of the Resident Fellows, of Dr. Charles Beck, Vice-President of the Academy, and of Dr. Whewell, of the Foreign Honorary Members.

The Secretary read a letter from the Treasurer of the Boston Athenæum to the Treasurer of the Academy, informing the Academy of the termination, on the 1st of July next, of the lease of the Academy's Hall, and notifying the Academy that the Trustees of the Athenæum propose to take possession of the Hall, after that date, for the use of the Athenæum.

On the motion of Mr. Bowditch the subject of this communication was referred to the Finance Committee, with powers to

make such arrangements with the Boston Athenæum as they may find feasible and deem expedient.

On the motion of Mr. Paine it was voted that application be made to the representatives of the late Jonathan P. Hall, for the meteorological observations made by him during the past nine years under the auspices of the Academy, and forming a sequel to the observations of Mr. Hall already published by the Academy.

Mr. Paine was appointed to make this application, and also to receive the apparatus furnished by the Academy for Mr. Hall's use.

Mr. C. M. Warren presented the following paper: —

Note on an Improved Apparatus for the Determination of Vapor Densities by Gay-Lussac's Method; being a Modification of Bunsen's Apparatus for measuring Aqueous Vapor. By C. M. WARREN.

HAVING recently had occasion to employ the method of Gay-Lussac for taking vapor densities, I decided to follow the lead of Carius,* and substitute for this purpose the steam-bath apparatus, Fig. 1, devised by Bunsen,† for measuring the aqueous vapor formed in the analysis of gases, — this seeming to me preferable to the apparatus described by Gay-Lussac. But when I came to use the apparatus which I had constructed, in conformity, as I supposed, with that of Bunsen, I found it defective in one particular. I allude to the fact that, in consequence of the accumulation of a stratum of water on the surface of the mercury in the cup *i*, Fig. 1, in which the measuring-tube, *e*, stands inverted, and also of an accumulation of water in dew-like drops on the sides of this cup, and on the sides of the cylinder *c c*, it was found impossible to make an accurate reading of the lower level of mercury.‡

As I was about to abandon the use of this apparatus and resort to that of Gay-Lussac, it occurred to me that the defect above mentioned

* Annalen der Chemie und Pharmacie, CXIX. 316.

† Gasometrische Methode, p. 52; English edition, p. 47.

‡ It is but just to remark, that my apparatus may have been defective in its proportions, — as dimensions were not given in Bunsen's description, — for it does not appear that either Bunsen or Carius had any difficulty in making accurate observations with the apparatus that they employed.

might be entirely remedied by supplying an additional cup, *n*, Fig. 2, within the other; the inner cup being of such capacity that the mercury expelled from the measuring-tube during an experiment would be certain to cause an overflow of mercury (no matter how little) from the inner into the outer cup. With such an arrangement it is obvious that at the time of measurement the inner cup would be always full of mercury, and consequently that the latter would always stand at the same level on the measuring-tube; hence that this level may be previously ascertained, once for all, and thus obviate the necessity of making this reading during an experiment. It will then only be required to make the single reading at the upper level of the mercurial column. The difference between this level and the constant level, previously ascertained, at the top of the mercury in the inner cup, will give directly the height of the column of mercury, which, corrected for temperature, is to be deducted from that of the barometer to find the pressure to which the vapor is subjected.

Fig. 1.

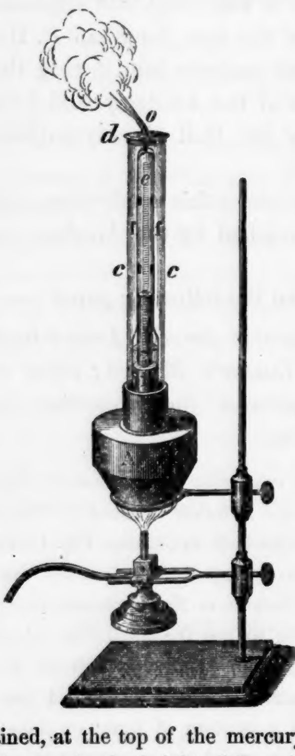


Fig. 2.

With this slight alteration of Bunsen's apparatus, it appears to me far preferable to the more complicated and expensive apparatus of Gay-Lussac. It has not only the advantage of greater simplicity, and of economy in the quantity of mercury required, but recommends itself also for its convenience, and the facility with which the vapor may be brought to and maintained at a constant temperature.

Five hundred and sixty-sixth Meeting.

April 24, 1866. — Special Meeting.

The President in the chair.

The President read a letter from Mr. Samuel F. Dalton, administrator of the estate of the late Jonathan P. Hall, transmitting to the Treasurer the sum of one hundred dollars, the bequest of Mr. Hall to the Academy, "to be expended in publishing its memoirs and transactions."

On the motion of Professor Lovering it was *voted*, That the thanks of the Academy be communicated to the representatives of Mr. Jonathan P. Hall for this acceptable bequest.

On the motion of Professor Bowen a committee of six was appointed to act with the Finance Committee on the subject of the purchase or lease of a Hall for the use of the Academy. The following gentlemen were appointed on this committee: Mr. Loring, Dr. J. Bigelow, Mr. E. B. Bigelow, Mr. J. A. Lowell, Mr. Andrews, and Professor Rogers.

Five hundred and sixty-seventh Meeting.

May 1, 1866. — Special Meeting.

The President in the chair.

Dr. J. Bigelow presented a report from the committee to consider the purchase or lease of rooms for the Academy.

On the motion of Professor Lovering it was voted to consider the subject of this report at the meeting to be held on the 8th of May; and the same committee was requested to investigate the subject further.

Mr. Loring was excused from further service on this committee, and Professor Eliot was appointed in his place.

Five hundred and sixty-eighth Meeting.

May 8, 1866. — Monthly Meeting.

The President in the chair.

The Corresponding Secretary read letters relative to exchanges; also letters from the Reverend Barnas Sears, President of Brown University, and from Dr. Joseph Dalton Hooker, Director of the Royal Gardens, Kew, in acknowledgment of their election into the Academy.

Professor Lovering reported, from the Committee of Publication, that Volume VI. of the Proceedings had been completed and was ready for distribution.

On the motion of Professor Lovering it was *voted*, That the sum of one hundred dollars bequeathed to the Academy by the late Jonathan P. Hall, for the publication of its memoirs and transactions, be appropriated to the publication of Mr. Hall's meteorological observations.

Dr. Bigelow reported, from the committee to consider the purchase or lease of rooms for the use of the Academy, that no further action had been had on the subject.

On the motion of Mr. Bowditch the subject of this committee's previous report was indefinitely postponed, and the committee was discharged.

The whole subject of the accommodation of the Academy was then referred to a new committee, consisting of Dr. Bigelow, the Treasurer, Mr. Bowditch, Professor Cooke, Professor Eliot, and Mr. J. A. Lowell.

Five hundred and sixty-ninth Meeting.

May 29, 1866. — Annual Meeting.

The President in the chair.

The Treasurer presented his report, which was accepted and referred to the Auditing Committee.

The Treasurer reported, from the committee to consider the subject of a building for the accommodation of the Academy,

that negotiations were pending for the further lease of the Hall now occupied by the Academy. The subject was recommitted.

The Corresponding Secretary read, in abstract, the following

Report of the Council.

Through a wholly unprecedented mortality, the Academy has lost during the past year seventeen members, among them its Vice-President and its Treasurer. Six of our deceased brethren were Resident Fellows, three were Associates, and eight Foreign Honorary Members.

Of the Resident Fellows thus removed, five were of the Third Class, comprising the honored names of Sparks, Beck, Livermore, Worcester, and Fitzpatrick, and one, Mr. J. Patten Hall, was of the Second Class.

JARED SPARKS was born at Willington, Connecticut, in 1789. His boyhood was passed in the then usual pursuits, and with no more than the then wonted opportunities and privileges of boys in the country. He, however, early manifested a strong inclination and capacity for mathematical study, and, with such aid as he could derive from stray books on navigation that fell in his way, he attained to the calculation of eclipses and other astronomical phenomena, and in one instance furnished the *mutanda* for the year's almanac. He learned a carpenter's trade, and connected with it the profession of a district schoolmaster. With no distinct purpose other than that of qualifying himself for the successful and honorable discharge of this last-named calling during the winter months, he sought the tuition of his pastor, Rev. Mr. Loomis, (afterward President of Shurtleff College, Illinois, and still living,) and under his direction commenced a course of classical study, undertaking to pay Mr. Loomis by shingling his barn. One day, when he was at work on the barn, his teacher asked him to come into the house, and construe a passage in Virgil in the hearing of Rev. Mr. Abbot, then minister of Coventry. Mr. Abbot perceived at once the rich promise that there was in the young carpenter, and wrote to his brother-in-law, the principal of Exeter Academy, to solicit a scholarship for him. The application was successful, and young Sparks walked to Exeter, more than a hundred miles, in three days, Mr. Abbot (who with his wife was meditating a visit to his brother and sister) conveying his trunk behind his own chaise.

After a novitiate, in which he showed masterly power of acquisition,

he entered Harvard College in 1811. Though his straitened circumstances made long absences for school-keeping necessary, and his health at one time was greatly impaired, he yet maintained a high college rank, and, in mathematics especially, was regarded as at the head of his class. After graduating in 1815, by invitation of the late Stephen Higginson, Esq., he taught a private school at Lancaster, Massachusetts, in the parish of Rev. Dr. Thayer, with whom he commenced the study of theology while engaged in the instruction of his sons. About this time he thought seriously of devoting himself to the scientific exploration of unknown regions. Mungo Park's Travels had interested him peculiarly in Africa, and arrangements were nearly completed for his entering the service of an English society for African research. The negotiation failed through no backwardness on his part, and from causes which he never fully understood.

In 1817 he was recalled to Cambridge, as Tutor in Mathematics and Natural Philosophy, and during the two years for which he held this appointment he completed his preparation for the ministry. In 1819 he was ordained pastor of a new Unitarian Church in Baltimore. Here he found himself unwillingly drawn into two separate controversies, — one with Rev. Mr. Wyatt, of Baltimore, on "The Ministry, Ritual, and Doctrine of the Protestant Episcopal Church"; the other with Rev. Dr. Miller, of Princeton, on the "Comparative Moral Tendency of Trinitarian and Unitarian Doctrines." The letters written in these controversies respectively were published in separate volumes, which, while they are monuments of their author's extensive learning and marked polemic ability, are admirable for their genial temper, their uniform courtesy, and their entire freedom from bitterness and invective. It is worthy of emphatic notice, that both of the divines who were then his earnest antagonists became his warm personal friends. He at the same time edited a monthly theological magazine, for which he furnished the greater part of the materials. He also commenced the editorship of a Collection of Theological Essays and Tracts by various authors, with biographical and critical notices by his own hand, — a work undoubtedly suggested by that well-known series of tracts bearing the name of Bishop Watson. This work was continued through six volumes. During a portion of his residence in Baltimore he served as Chaplain to the House of Representatives in Congress, at a period when that office was not, as now, scrambled for by greedy seekers, but conferred unsought on the best man.

In 1823 he resigned his charge at Baltimore on account of enfeebled health. He then removed to Boston, and became proprietor and editor of the North American Review. During the seven years for which this work was entirely under his control, it reached a degree of prosperity and an extended circulation which it has never equalled at any subsequent time. In 1828 he published a "Life of John Ledyard, the American Traveller."

Shortly after his removal from Baltimore he determined to attempt the publication of Washington's Life and Writings. In 1828 he spent a year in Europe, employed principally in copying documents illustrative of the history of the American Revolution in the public archives of England and France. His great work appeared in twelve volumes, in 1834–37. During its preparation, and chiefly from materials accumulated in its furtherance, he published the "Life and Correspondence of Gouverneur Morris," in three volumes, and the "Diplomatic Correspondence of the American Revolution," in twelve volumes. The American Almanac, from the outset a work of national interest and importance, was also started by him, and he edited its first volume, — that for 1830. Simultaneously with the appearance of the first volume of his Washington, he commenced the publication of his "Library of American Biography," which was continued through twenty-five volumes, several of the memoirs having been written by himself, and all the rest written by authors of his own procuring, and published under his immediate supervision. In 1840 he completed, in ten volumes, his Life and Writings of Franklin. In 1854 he published four volumes of the more important Correspondence of the American Revolution. In these labors he easily takes the lead of the historians of the United States. No other man has approached him either in the amount or the value of his contributions. He has done more, perhaps, than all others to make it possible that a history of the American Revolution should be written. His works bear abundant tokens of his conscientious faithfulness, his judiciousness as an historical critic, his freedom from prejudice and partiality, his perspicuity, grace, and dignity as a writer, his sound judgment as an editor, and his skill in availing himself of the cooperation of others. It is believed that no one has ever covered so much ground with so few assailable points; and the two or three instances in which he has been called in question have only served to bring into clearer view the patient industry, profound discretion, and

single-hearted rectitude with which he had managed the many difficult subjects that came under his treatment.

From 1839 to 1849 he was Professor of History in Harvard College, and he was its President from 1849 to 1852. Since retiring from the Presidency he has written little. It was his intention to write an extended history of the United States, and he regarded his previous labors as but a preparation for this. But a lameness of the right arm precluded the free use of the pen, and the conscious difficulty of so changing all his habits of study, note-taking, and composition as to conform himself to the use of an amanuensis postponed the commencement of this plan till it was too late to carry it into execution. He continued to live at Cambridge, surrounded by many of his early friends, and by many more by whom he was equally revered and loved. On the evening of March 6th, 1866, he was at a social party. On his return home he was seized with chill, and on the next day pneumonia set in, at his age with little or no hope of recovery. His sufferings were probably not severe; if they were, he bore them in perfect serenity, and remained cheerful and self-collected till a comatose condition ensued but a few hours before his death. He died on the 14th of March.

Mr. Sparks did nothing that was not done well, few things that were not done superlatively well. His reputation rests not merely on his capacity as an editor and compiler: had he written nothing else, his biographies alone would have seemed work and glory enough for one man; and these, in the appreciation of their subjects, in the grouping of persons and incidents, in the delineation of character, and in the tracing of relations and sequences among events, give ample evidence of a keen insight, an analytic faculty, and a constructive power, which the literary world would have better appreciated, had not his more important biographies, those of Washington and Franklin, been in form subsidiary to the publication of their works.

In his private character no ordinary terms can convey the measure in which he was honored and loved, most by those who knew him best. He can have had no enemies; and no man can have made more or warmer friends. In meekness, modesty, kindness, generosity, a winning politeness that went to the heart because it came from the heart, the most tender concern for the well-being and happiness of others, constant watchfulness for the opportunities of doing good, charity that

dropped its benefactions in look, word, and deed all along his life-path, — in these and other like traits he realized to many, with more fulness than they can readily recall it elsewhere, the ideal of a Christian gentleman. And it was his happiness and ours that he died, though full of years, before the infirmities of old age had impaired either his capacity of enjoyment, or — what would have been to him the same thing — the power of active beneficence. "*Felix, non vitæ tantum claritate, sed etiam opportunitate mortis.*"

Charles Beck, late Vice-President of the Academy, died in Cambridge, March 19, 1866, after an illness of only three hours. He was the son of a merchant, and was born at Heidelberg on the 19th of August, 1798. His mother afterwards marrying for her second husband Professor De Wette, the family moved to Berlin in the year 1810, when De Wette, then about thirty years old, and already widely known as a theologian, was called to a chair in the new University.

The boyhood and early youth of Dr. Beck were passed partly in Carlsruhe and partly in Berlin, in which latter place he enjoyed unusual advantages. He was a pupil in the Werder Gymnasium, where, among other instructors, he had the elder Zumpt: his step-father's literary and social position gave him an opportunity of seeing and hearing the gifted men in whom Berlin then abounded; and the events of the War of Liberation, going on before his eyes, awakened in him a spirit of patriotic fervor which never died out, and which made his example and influence of great worth in after days to his adopted country. Indeed, the chances of war made his home at times unsafe for women and children: on one occasion it was thought best for his mother to leave town, and as she travelled with her son they listened all day to the roar of Napoleon's guns. The day after the battle of Grossbeeren, not far from Berlin, August 23, 1813, he visited the battle-field, and was vividly impressed with the dreadful reality of the contest in which his country was engaged. He was one of the patriotic pupils in the Gymnastic School of Jahn, established near Berlin in 1811: he belonged also to the Band of Virtue, an association which embraced the flower of the German youth, and to the Burschenschaft.

The lessons of this period were not lost upon young Beck. His well-knit frame was made strong and supple by the manly exercises for which he retained a love all his life. His mind, naturally of a hardy mould, acquired great force and a set determination. With the shrewdest practical judgment, with the soundest common sense, he was always ready to sacrifice everything to his ideas of right.

During his career as a student at the University an incident occurred which gave a direction to his whole life. His stepfather, Professor De Wette, who had enjoyed the hospitalities of the parents of the student Sand, the assassin of Kotzebue, wrote a letter of condolence to the mother of the unhappy young man. Although the letter, far from justifying the deed, merely pointed out general sources of Christian consolation, the Prussian government was not inclined to pass it by unnoticed: on the 28th of August, 1819, Professor De Wette was asked if he acknowledged the authorship of the letter; two days after he was summarily dismissed from the University. After an interval of three years he was called to the University of Basle as Professor of Theology. His step-son meantime having finished his theological and philological studies at the University of Berlin, and after passing his examination as candidate of theology, having been ordained as a clergyman in Heidelberg (July 7, 1822), left Germany and joined his step-father at Basle in the same year, and spent the next two years as a successful Teacher of the Latin Language and Literature in the Pedagogium at Basle. During this time he took the degree of Doctor of Philosophy at Tübingen (September 18, 1823).

The state of affairs in Germany and Switzerland convinced Dr. Beck that there was no field in either of these countries for one of his sentiments. He left Switzerland accordingly in the year 1824, and came to this country with his valued friend, Dr. Follen. They landed in New York, December 24th. The testimonials and letters brought with him insured him a favorable reception at once. As an evidence that America was henceforth to be his permanent home, Dr. Beck took the preliminary steps to being naturalized in Philadelphia, a month after he landed: he was naturalized in Northampton, March, 1830. The first five years of his American life were passed in Northampton, in the well-known Round Hill School of Messrs. Cogswell and Bancroft. At this school Gymnastics were taught for the first time in America. In 1830, he on the Hudson opened a school of his own for boys. Two years after, in the beginning of 1832, he was called to Harvard College as University Professor of Latin, and remained in that office till 1850. After his resignation he was occupied with his own private studies, and with many trusts of a public character, till his death. He was twice a member of the Legislature, Vice-President of the Oriental Society, President of a Savings Bank, and Director of another Bank, and a valued member of many boards and commissions in his own town.

Dr. Beck visited Europe three times; once in 1847, again in 1857, and the last time in 1858. The last journey was undertaken principally for a literary purpose.

In 1856 he published in the Memoirs of the Academy a most important contribution, on the Age of Petronius Arbiter, in which he takes ground against the hasty conclusions of Niebuhr and Studer, and exhausts the treasures of antiquity and language to prove that this puzzling fiction must have been written either in the reign of Augustus or Tiberius. Finding that the text of Petronius was in a very untrustworthy state, he resolved to collate the manuscripts himself. On his last journey to Europe, in 1858 and 1859, he compared twenty of the twenty-one existing manuscripts of Petronius. The results of these studies he published in a beautiful quarto volume, printed in Cambridge, 1863, at his own expense, and distributed gratuitously. It is not hazardous to say that the manuscripts of no author have ever been collated with a more minute and conscientious accuracy than those of Petronius. It was hoped by Dr. Beck's friends that he might feel inclined to edit Petronius, a task for which he was so peculiarly qualified. He was prevented from doing this partly by occupations which he considered more important, and partly by the publication of a new Petronius in Germany. Beside the two works alluded to, he published a third bearing the name of Petronius, an inedited lexical fragment discovered by him and printed in Vol. VIII. of the Memoirs of the Academy. In former years he had published a number of works; among which were a Treatise on Gymnastics, Northampton, 1828; the Medea of Seneca, 1834; Cicero's Brutus, 1837, and in an entirely new edition, 1853; Latin Syntax, 1838, and a second edition, 1844; the Hercules Furens of Seneca, 1845; Munk's Metres of the Greeks and Romans, (translated with Professor Felton,) 1844; and beside this he had contributed to literary journals.

The same conscientious fidelity which marks his writings pervaded all he did. The rule of his life was to do his duty as he understood it, and the whole of his duty, without fear or favor, and to do all he could for his fellow-men. As an instructor he was rigorous and exacting, but not more so toward his pupils than toward himself. In the distribution of his means he showed judgment as well as generosity. His contributions to the various public calls that have been so frequent, of late years particularly, have been munificent. But his private charities have undoubtedly been greater still. No deserving foreigner ever appealed to

him for aid in vain; and it was his habit to seek out intelligent young American mechanics of good character, and lend them money to begin their trade. As a citizen he was a model man. He took a warm interest in all public matters, national and state; he was more thoroughly informed about municipal affairs than most born Americans. From the first outbreak of the war he did all he could to help the national cause. He thought that every good citizen should serve his country as far as he could in person, and showed his sincerity by joining a military organization and drilling with the zeal of the youngest recruit. He went with his company into camp, where he was eager to do all the drudgery of a common soldier; and it was a sore trial to him that when the company went into service he was rejected on account of his age. The universal respect in which his lofty integrity and simplicity were held was touchingly attested at his death, which was mourned by the citizens as a great public calamity.

Mr. George Livermore died at his residence on Dana Hill, in Cambridge, on Wednesday, August 30, 1865, of a disease of the veins, followed by paralysis.

He was a son of Nathaniel and Elizabeth (Gleason) Livermore, and was born in Cambridge, July 10, 1809, being therefore at the time of his decease in his fifty-seventh year. He had been shortly before chosen Treasurer of the Academy, glad, as he said, — with that pleasing modesty which was one of the most winning traits of his attractive character, — to prove his interest and good-will as a Fellow, in an office which did not require the high scientific qualities displayed by his brethren. To all his associates in literary pursuits, and to all who met him in the walks of trade and business, he was known (as only in the more private circles of affection he could be fully appreciated) as a man of rare excellence of native disposition, of lofty integrity, ardent patriotism, and fulness and depth of Christian principle and culture. There was a charm in his gentle bearing, and a grace in his speech and manners which made him a most delightful companion, and impressed all who were brought into contact with him. There was something singularly engaging in his refined simplicity and quietness of spirit, and in the almost feminine delicacy of his nature. Indeed, perhaps even his nearest friends would not have fully known what energy and almost passionate earnestness were latent in that nature, had they not been called out by the perils and struggles of his country during the last four years of his life. An all-absorbing patriotism stirred him to the

intensest interest in the war against the rebellion. The delicacy and feebleness of his body alone prevented his becoming a soldier, but his pen and purse, his zeal and practical effort, were devotedly given to filling the ranks of our army, promoting enlistments, gathering recruits, providing for the welfare and comfort of soldiers on the march, in the camp, on the battle-field and in the hospital, and even to furnishing them with copies of a reprint of the famous "Soldiers' Bible" of the Cromwellian troopers. It was with a view of meeting one of the most exciting of the issues which the war incidentally opened, that he was led to the investigations that resulted in the most elaborate production of his pen. His "Historical Research respecting the Opinions of the Founders of the Republic on Negroes as Slaves, as Citizens, and as Soldiers," an epitome of which he read before the Massachusetts Historical Society, in August, 1862, is one of the most thorough, comprehensive, and exhaustive productions to be found in our historical literature. After his searching investigations had made him master of the whole field covered by his subject, he published the result, at his own cost, in very many forms, some of them elegant and expensive, and distributed them far and wide. Senator Sumner asserts, as of his own personal knowledge, that President Lincoln made use of this valuable "Research," while preparing his own final Proclamation of Emancipation.

Mr. Livermore had in his early years only those means of education which Massachusetts offers to all her youth; and as soon as his school training was completed, he entered upon the mercantile and business occupations which he pursued for the remainder of his life. In these he was so far successful as to possess himself of ample means for gratifying his fine literary taste and his strong desire for studious culture. The library which he gathered, at great cost, was in itself a remarkable collection, and indicative of the qualities of his mind and character. A visit to Europe had afforded him facilities which he diligently and wisely improved. Without yielding to the mere fancies of the bibliomaniac, he availed himself of them for uses of wisdom. His collection of Bibles, among which was one that had belonged to Melancthon, and of works illustrating the Scriptures by art, was unique and extremely rich. He was a diligent student of American history, seeking for rare tracts and original materials. He had a conscience for accuracy and thoroughness in his researches, and several of the pieces which he published prove a very wide and curious knowledge,

obtained by him through processes which justified his challenging the deliberate judgments and statements of professional scholars and historians. He made contributions to the North American Review and to the Christian Examiner. For fifty years a pupil or a teacher in a Sunday school, he was also an efficient worker in the cause of education in his native place. Harvard College, of whose Library Committee he was a valuable member, gave him the honorary degree of A. M. in 1850. Mr. Livermore was a Trustee of the State Library and of the Boston Athenæum, a member of the American Antiquarian Society and of the Massachusetts Historical Society.

JOSEPH EMERSON WORCESTER died in Cambridge, after a brief
27 illness, October 21, 1865. He was born in Bedford, New Hampshire, August 24, 1784, the second in a family of fifteen children. In 1794 he removed to Hollis, N. H., where he resided till he became of age, assisting his father in labor on the farm. During this period his opportunities for education were limited, but he early manifested an ardent thirst for knowledge; and it is related that after the toils of the day he often sat up till midnight or later in company with his elder brother, Jesse, reading Rollin's Ancient History, Josephus, and similar works, by the light of pitch-pine knots. At the age of twenty-one, though entirely dependent on his own exertions for support, he resolved, if possible, to obtain a liberal education, and began his preparation for college at Phillips Academy in Andover. He afterwards pursued his studies for this purpose at Boscawen and Salisbury, N. H., and especially at Salem, Mass., where he spent two years or more in teaching. In 1809 he entered the Sophomore Class in Yale College, and was graduated in 1811. After leaving college, he was again employed in teaching for several years in Salem, where he commenced the preparation of his first work, a "Geographical Dictionary or Universal Gazetteer, Ancient and Modern," which was published at Andover in 1817, in 2 vols. 8vo. (A new edition, greatly enlarged and improved, appeared in 1823.) This was followed by a "Gazetteer of the United States," published in 1818. In 1819, for the sake of greater literary advantages, he removed to Cambridge, which thenceforth became his permanent residence.

The same year he published his "Elements of Geography, Ancient and Modern," a work far superior to the previous text-books on the subject, and which passed through several stereotype editions. This was succeeded by his "Sketches of the Earth and its Inhab-

itants," in 2 vols., 12mo, Boston, 1823. His "Elements of History, Ancient and Modern," accompanied by an "Historical Atlas," admirably adapted to its purpose, was first published in 1826, and has probably been more extensively used in our schools than any similar manual. It has been repeatedly stereotyped. In 1825 Mr. Worcester communicated to the American Academy, "Remarks on Longevity, and the Expectation of Life in the United States, relating more particularly to the State of New Hampshire, with some Comparative Views in relation to Foreign Countries," which was published in Vol. I. of the Second Series of our Memoirs. His first production in the field of English lexicography, which he afterwards so successfully cultivated, was an edition of "Johnson's Dictionary as improved by Todd, and abridged by Chalmers, with Walker's Pronouncing Dictionary combined," which was published in Boston in 1828. In 1829 he was induced by Mr. Converse, the publisher of Webster's large American Dictionary, to prepare an abridgment of that work. His own "Comprehensive Pronouncing and Explanatory English Dictionary," which he had commenced before undertaking the abridgment of Webster, appeared in 1830. Its extensive list of words of various orthography, distinguishing the form commended by the best usage and, in the case of words differently pronounced by orthoepists, its exhibition of the principal authorities for the pronunciation, were novel features of the work, which greatly contributed to its popularity. Its publication gave occasion to an ill-considered charge of plagiarism on the part of Dr. Webster, who enumerated one hundred and twenty-one words which he regarded as pirated from his Dictionary. Mr. Worcester's reply must be regarded as completely triumphant, and, as a specimen of good writing, has not often been surpassed in literary controversy.

Near the close of the year 1831, Mr. Worcester made a voyage to Europe, where he spent about seven months, visiting many of the chief places of interest in England, Scotland, France, Holland, and Germany, and furnishing himself with the literary apparatus required for more extensive researches in his chosen fields of labor. In the year 1831 he assumed the editorship of the "American Almanac," which he conducted for eleven years with eminent success. His "Universal and Critical Dictionary of the English Language," the fruit of many years of labor and study, appeared in 1846, and gave occasion to the famous "War of the Dictionaries," waged with so much ferocity by the rival publishers. No person was ever less disposed than Dr. Worcester to

disparage the merit of a fellow-laborer, and the spirit of the whole controversy was utterly uncongenial with his feelings. It became necessary for him, however, to expose a gross literary fraud, when the work just referred to was issued by an unscrupulous London publisher with a garbled Preface, and the utterly false title, "A Universal, Critical, and Pronouncing Dictionary of the English Language, ... *compiled from the Materials of Noah Webster, LL. D.*, by Joseph E. Worcester." A pamphlet setting forth the facts in the case was published by him in 1853, and enlarged with a third Appendix in 1854.

In 1847 – 49 Dr. Worcester experienced one of the severest trials that can befall a scholar, in the threatened loss of sight, and the actual inability to use his eyes for reading, or hardly any other purpose, for about two years. During this period he had three operations performed on his right eye for cataract, and two on his left, the last of which, happily, was entirely successful. This great affliction was borne throughout without a murmur, in the spirit of true Christian resignation and trust.

In 1847 Dr. Worcester published an enlarged and improved edition of his Comprehensive Dictionary, which contained, among other additions, a "Vocabulary of Modern Geographical Names," with their pronunciation. This volume was still further improved and enlarged in 1849; and in 1855 it appeared with the title, "A Pronouncing, Explanatory, and Synonymous Dictionary of the English Language"; the discrimination of synonymes being an important and distinguishing feature of the work. It also contained a list of the Christian Names of Men and Women, with their etymological signification, introduced for the first time in an English dictionary.

The crowning literary labor, however, of Dr. Worcester's life was his "Dictionary of the English Language," published in 1860, in a large and beautifully printed quarto volume of one thousand eight hundred and fifty-four pages. In the preparation of this work, the author was aided by a number of able and industrious collaborators, and in the explanation of terms of a technical character he enjoyed the assistance of men eminent in various departments of literature and science, including some of the most honored members of the American Academy. The various appendixes of Classical, Scripture, and Geographical Names, and of Names of Distinguished Persons of Modern Times, were all elaborated anew, and made, it is believed, far more complete and accurate than in any preceding work. It will not be deemed invidious to

say, that, at the time of its publication, notwithstanding the great merits of its chief competitor, the general verdict of scholars at home and abroad placed it at the head of English lexicographical literature; and if it has since been equalled or surpassed, we may indulge a pardonable pride in the fact, that the only dictionary of the English language which even now can pretend to rival it in fulness and accuracy is also the product of American enterprise, industry, and scholarship.

All the works of Dr. Worcester give evidence of sound judgment and good taste, combined with indefatigable industry and a conscientious solicitude for accuracy in the statement of facts. The tendency of his mind was practical rather than speculative. As a lexicographer, he did not undertake to reform long-established anomalies in the English language: his aim was rather to preserve it from corruption; and his works have certainly contributed much to that end. In respect both to orthography and pronunciation, he took great pains to ascertain the best usage; and perhaps there is no lexicographer whose judgment respecting these matters in doubtful cases deserves higher consideration. In the mazy paths of etymology, if he cannot claim the merit of an original explorer, his good sense preserved him from the wild aberrations and extravagances into which many have been misled. His definitions, for neatness and precision, will not suffer, perhaps, in comparison with those of any of his predecessors; but it must be confessed that all our English dictionaries too often mistake a special application of a word for an essential change of meaning, and hide its precise signification in a cloud of undiscriminated synonymes.

In 1827 Mr. Worcester was elected a member of the Massachusetts Historical Society; and he was an Honorary Corresponding Member of the Royal Geographical Society of London. He was also one of the earliest members of the American Oriental Society. In 1847 he received the degree of Doctor of Laws from Brown University, and afterwards from Dartmouth College.

Though somewhat cautious and reserved in the expression of his feelings, Dr. Worcester was a man of strong affections, and great benevolence of character. He delighted especially to render aid to those who, like himself in early life, were struggling with difficulties in the pursuit of knowledge; and his sympathy for the poor and unfortunate was warm and active. During the late contest for the maintenance of the Union, and of the principles which lie at the foundation of our Republic, he was thoroughly patriotic. He had no children to conse-

crate to the cause, but nine of his nephews served in the United States Army, whom he encouraged by constant correspondence; and the various charities of the war met from him a ready and liberal response to their calls. Closing his earthly career at the advanced age of eighty-one years, he has left behind him the memory of a useful and spotless life; and by his literary labors he has not only won a title to the gratitude and respect of his countrymen, but of all who speak and write the English language.

The Right Rev. JOHN BERNARD FITZPATRICK was the son of Irish parents, of humble circumstances but earnest piety, who came over to America in 1805. Born in Boston on the 1st of November, 1812, he owed his early education to the common schools of his native city. He was a pupil successively of the Adams and Boylston Schools, and afterwards for three years of the Boston Latin School. He seems to have been a most exemplary and diligent scholar, having twice received the Franklin medal, besides obtaining several other prizes for excellence in special departments of study. From his earliest youth he was the subject of deep religious impressions, and found his highest satisfaction in the teachings and services of the Church to which his parents belonged. To that church and its ministry he soon resolved to devote his life, and with this view he broke off from his secular studies, and left his home at seventeen years of age to enter the Roman Catholic College at Montreal. After four years of faithful study in that institution, he greatly distinguished himself by the part which he took in a public disputation in four languages, — Latin, Greek, French, and English, — and was immediately thereafter appointed Professor of Rhetoric and Belles-Lettres. In this capacity he spent four years more at Montreal, and thence repaired for the completion of his theological preparation to the great Seminary of St. Sulpice in France. He was connected with this seminary for nearly three years, and was not less devoted or less distinguished as a scholar at Paris than he had been at Boston or Montreal. The time had now arrived for him to enter on the practical duties of the ministry. In May, 1839, he received the order of sub-deacon. In December of the same year he was ordained a deacon, and in the following year was promoted to the priesthood. Recrossing the Atlantic in November, 1840, he returned at once to his native city, where for a year or two he was occupied with pastoral duties at the Cathedral or at St. Mary's Church. During another year or two, he held the pastorate of East Cambridge. But higher duties soon awaited him,

and in 1844, at thirty-two years of age, he received the appointment of Coadjutor to the Bishop of Boston, — the health of Bishop Fenwick requiring him to relinquish in part the care of the Diocese. He was consecrated Coadjutor in March, 1844, and on the death of Bishop Fenwick, a little more than two years afterwards, he succeeded to the full duties and dignities of Roman Catholic Bishop of Boston.

It was no light responsibility for any one to succeed to an office which had been held before only by the excellent Fenwick and the sainted Cheverus. Of the latter, at least, it may safely be said, that no ecclesiastic of any sect or denomination who ever lived in Boston has left behind him a more enviable memory. The charm of his conversation, the humility of his manners, the simplicity of his life, the untiring benevolence and beneficence which he exhibited towards the suffering poor, endeared him to the whole community; and his departure for France in 1823, to become the Bishop of Montauban, and afterwards Archbishop of Bordeaux and a Cardinal, while all acknowledged the justice of the promotion, was the subject of deep and wide-spread regret. It is enough to say of Bishop Fitzpatrick, that he proved a worthy successor to the eminent prelates who preceded him. He was a man of an excellent spirit, of a genial temper, of peculiar tact and sterling common-sense, of rare accomplishments, of a noble presence; without anything of presumption or ostentation, yet of striking dignity; shrinking from all display, except such as was inseparable from the ceremonies of the Church over which he presided, and devoting his whole time and thoughts and strength to the care of his diocese. He had, indeed, too little self-appreciation for his own worldly fame, and has left no record of his learning and acquirements except in the memory of those who knew him. He seldom delivered formal discourses. He engaged in no doctrinal controversies. He wrote no theological essays. He committed absolutely nothing to the press. Not a single pamphlet, hardly a single printed page, is left to preserve his name in our libraries. But his memory will be cherished in the hearts of the whole religious denomination to which he belonged, and in those of a large circle of personal friends of all denominations.

His devoted labors in the Episcopacy for twenty years proved too much for his strength and health. He sought relief and restoration in foreign travel, but returned after an absence of two or three years without permanent benefit, and died in Boston on the 13th of February 1866, universally respected and lamented.

JONATHAN PATTEN HALL was born in Medford, Massachusetts, July 22, 1799, and died in Boston on March 6, 1866. He was fitted by Daniel Staniford for Harvard College, where he was graduated in 1816. His own inclination was for a student's life, particularly for the profession of medicine; but he yielded to the wishes of his father, and was engaged with him in business as a druggist for twenty-three years. Mr. Hall was interested in Chemistry and also in Botany. In 1821 he began to keep a regular journal of the atmospheric temperature, recording his observations three times a day. He continued this journal to within a few days of his death. The last observation recorded by himself was on November 13, 1865, but the work was done under his direction until March 1, 1866. On May 28, 1850, Mr. Hall was elected a Fellow of the Academy, and on the 14th of August of the same year he was appointed Meteorological Observer of the Academy. In 1858 he published his meteorological observations in the Memoirs of the Academy (Vol. VI. p. 229), under the following title: "Register of the Thermometer for Thirty-six Years, from 1821 to 1856, to which is added the Quantity of Rain falling in Boston, Mass., for Thirty-four Years, from 1823 to 1856." Mr. Hall was singularly shy and retiring in his nature, but in his unassuming way he served faithfully the interests of science. Harvard College and the American Academy of Arts and Sciences were equally remembered by him in his modest bequests; the former receiving one hundred dollars for its Library, and the latter an equal sum for its Publication Fund.

From our list of Associate Fellows we have to lament the loss of the Rev. Dr. Wayland, Bishop Alonzo Potter, and Colonel James D. Graham, — the two former distinguished for their learning and eloquence as divines, and for their zealous and fruitful labors in behalf of education, — the latter well known for his various services as an officer of the Corps of our National Engineers.

FRANCIS WAYLAND, the son of Rev. Francis and Mary Wayland (the father a Baptist clergyman of worth and reputation), was born in the city of New York on the 11th of March, 1796. He was graduated at Union College in 1813. He then made choice of the medical profession, in which he had completed a three years' course of study, when, deeming himself called to a more sacred field of service, he, in 1816, became a member of the Andover Theological Seminary. Here he remained but a year, and then accepted a tutorship in Union College, which he held for four years. In 1821 he became pastor of the First Baptist

Church in Boston, and during a ministry of only five years rose to as high a reputation as any American preacher has ever attained. It was at this time that he delivered, at an Andover anniversary, his celebrated Sermon "On the Moral Dignity of the Missionary Enterprise." It is said that the greatness of this magnificent discourse was hardly suspected even by the most appreciative of its hearers, so little was there then in the preacher's voice and manner to constrain attention; but it had no sooner issued from the press than it passed into rapid and extensive circulation, was republished in many successive editions on both sides of the Atlantic. The brilliant reputation thus won concurred with his previous success as a member of the Board of Instruction to procure for him an invitation to the Professorship of Mathematics and Natural Philosophy in his *Alma Mater*. Hardly had he entered on the duties of this office, when he was chosen President of Brown University. He promptly accepted the trust, and remained at the head of that institution for more than twenty-eight years. Though he resigned his presidency on account of impaired health, the few years that succeeded his resignation were a season of undiminished mental vigor and industry. During a temporary engagement as acting pastor of a church in Providence, he preached with greater eloquence and efficiency than at any previous time, and the printed sermons of this period transcend in vigor of thought, fervor of religious feeling, and the higher qualities of style and diction, all his earlier writings, the one master work excepted. He died in consequence of an attack of paralysis, on the 30th of September, 1865.

Dr. Wayland's publications have been numerous. Besides many sermons, lectures, and addresses, issued singly and in volumes, he was the author of valuable treatises for school and college use, on Political Economy, Mental Philosophy, and Moral Philosophy; the last of which has had a very extended circulation, and is believed to be more generally employed as a text-book in our colleges than any other manual in that department.

Dr. Wayland seemed born to command, and could not but have been a controlling mind in whatever sphere of life he might have chosen. Strong in his convictions, with not a little native impetuosity, which strenuous self-discipline directed rather than repressed, and with an energizing sense of right and duty in whatever he undertook, he usually succeeded not only in having his own way, but in drawing to it the current of surrounding opinion and feeling. In the administration of

the University he was inflexibly just, accurate, and thorough, solicitous to raise the intellectual and moral standard of the institution, and self-sacrificingly kind to students who deserved his kindness. Others may have won more love in their daily intercourse with their pupils; his students left him with a respect, which rose into reverence as they grew into sympathy with his lofty aims, and deepened into affection as they recalled the sincerity and earnestness of his endeavors to do them good. As a teacher, he was distinguished for the clearness of his expositions, the wealth of pertinent illustration which he brought to bear on every point, the enthusiasm he awakened, and the impulse to vigorous and independent thought which he imparted to his pupils.

As a writer, he was compact, clear, and strong. No style could be more free than his from rhetorical artifice. His most glowing discourses exhibit no outbreaks of sentiment or emotion, but have a sustained force and fervor which commands undivided attention.

In the private relations of life, Dr. Wayland was upright and faithful, unselfish and generous. As a citizen, he was public-spirited and philanthropic. No one could have been more loved, honored, and confided in than he was throughout the community in which the greater part of his life was passed.

The Right Rev. ALONZO POTTER was born in Beekman (now La Grange), New York, July 10, 1800. He entered Union College in 1814, was graduated in 1818, became Tutor in the following year, and two years later, at the age of twenty-one, he was chosen Professor of Mathematics and Natural Philosophy. Having meanwhile taken orders in the Episcopal Church, he accepted in 1826 the rectorship of St. Paul's Church in Boston, where in a ministry of but five years he won the enduring respect and affection of members of every Christian communion, and held a place second to none of his contemporaries among the clergy as a man of learning and ability, as an efficient and successful preacher, and as a devoted and faithful minister. In 1831 he was recalled to Union College as Professor of Moral Philosophy, to which office was shortly added that of Vice-President. In this latter capacity he had on his hands the principal portion of the interior discipline of the college, — financial engagements and the external affairs of the institution occupying the greater part of Dr. Nott's time. While here he continued in the frequent exercise of his profession, and was regarded as one of the pillars of his Church; so that, in the vacancy of the important Bishopric of Pennsylvania, he was chosen to that

office not only by the vote of the electing body, but equally by the approving suffrages of a widely extended public. He was consecrated as Bishop in 1845. He found his post of service as arduous as it was honorable, and for the first twelve years he performed an incredible amount of labor, both in the visitation of a diocese larger than some important kingdoms of the Old World, and in the preparation of sermons, charges, and other official papers, which continued to bear the marks of fresh, strong thought, and to betoken a mind no less industrious in his now crowded and care-cumbered arena than it had been during the quiet of his academic life. But his overtasked brain at length yielded to a stroke of paralysis in 1857. In 1858 he was relieved of a portion of his official duty by the appointment of an assistant bishop. A few months spent in foreign travel restored him to his work, which he was permitted for a few years longer to pursue with little less than his former vigor. But threatening symptoms again supervened, and by advice of his physician he sought relief by a sea-voyage. He took passage for California in a new steamer belonging to the Pacific Mail Company. From Panama he went to Aspinwall to consecrate a chapel. He was detained there over night, and was subjected to malarious influences, which, after he had embarked on the Pacific, issued in malignant fever. On arriving in the harbor of San Francisco he appeared so far convalescent that arrangements were made for his removal on shore. But a relapse ensued, and he died on shipboard, July 4, 1865.

Bishop Potter published, in addition to numerous pamphlets, a treatise on Political Economy for college use, and several other educational works. He was also the author of the first part of "The School and Schoolmaster," a work prepared by him in connection with Mr. George B. Emerson, and placed in every school-house in Massachusetts and New York.

He was an easy, graceful writer. His imagination, evidently vivid, else his words would not have been so transparent, was employed, not in imagery and ornament, but in the presentment of the objects of thought in their true aspects and relations. Never forsaking, postponing, or slighting the duties incumbent on him by virtue of his station, he was always ready to renounce needed rest or leisure in aid of any worthy cause. His services in behalf of the reformed system of common-school education will be beneficently felt long after they have ceased to be remembered.

In private life he was greatly and worthily beloved. Simplicity and sweetness of spirit and mien, tender thoughtfulness for all around him, with all the amenities and graces that go to constitute the Christian gentleman, marked his daily intercourse, won for him troops of friends, and made it hardly possible that he should have an enemy. In his ecclesiastical relations, while loyal to his own Church, and steadfast in his own convictions of truth and right, he lived in mutual esteem and in the interchange of the kindest Christian offices with good men of every denomination.

COLONEL JAMES DUNCAN GRAHAM, of the U. S. Engineers, was born in Virginia. He entered the United States service as Third Lieutenant of Artillery in the year 1817, was appointed a Captain (by brevet) of Topographical Engineers, January 15, 1829, and rose in this corps by the regular course of seniority to the grade of Lieutenant-Colonel; he was brevetted to this grade January 1, 1847, and obtained his actual commission for it, August 6, 1861. Upon the consolidation of the two corps of Engineers and Topographical Engineers, he received a colonel's commission in the combined corps, which he held at the time of his decease, December 28, 1865.

His scientific labors have been for the most part either directly in the line of military engineering duty, or incidentally connected therewith. Of the former class were his labors upon the Northeastern Boundary and Mexican Boundary Commissions, and upon the survey of the Northern and Northwestern Lakes. He was very assiduous as an instructor in practical astronomy to the younger officers under his command, and was himself an admirable observer. The latitudes and longitudes of the points upon our Northeastern Boundary were determined by him and his subordinates with great precision. He often availed himself of his travels in this line of duty to contribute largely to the advancement of American geography, and his determinations are always very accurate, though often made with apparently inadequate means. Thus a large number of the most accurate positions yet determined of our Lake ports, are due to his sextant observations made within ten years, while he was in charge of the Lake Harbor improvements.

Colonel Graham was an admirable example of a military astronomer, — a class to whom in every country a great deal of the progress of astronomical geography is due.

From the roll of our Foreign Honorary members it becomes our sad duty to withdraw the names of Encke, Lubbock, Sir William Rowan

Hamilton, Whewell, Sir William Hooker, Lindley, Admirals Smyth and Duperrey, all distinguished in the walks of science, and most of them illustrious for their original investigations.

John Francis Encke was born in Hamburg, September 23, 1791. His father was a deacon in the Jacobi Church. After completing the course of study of the college or gymnasium in Hamburg, he entered the University of Göttingen in October, 1811, where he remained a student under the instructions of Gauss until the spring of 1813, when he entered the army and marched to Hamburg for the rescue of his country from the domination of the French. After the fall of Hamburg he entered the Hanseatic Legion, and served in the horse artillery until June, 1814. In the autumn of this year he returned to Göttingen and resumed his studies. In 1815 he entered the Prussian service for a short time. After the battle of Waterloo and the restoration of peace he completed his studies under Gauss, and was appointed assistant to Lindenau, in the Observatory of Lemburg, in 1816. He received the title of Professor in 1818, of Vice-Director in 1820, and in 1822 he succeeded Lindenau as Director of the Observatory. In 1825, at the recommendation of Bessel, he was appointed Director of the Observatory at Berlin. He died in Spandau, of disease of the brain, on the 26th of August, 1865, having been relieved from all astronomical work, in consequence of the approach of the disease, from the beginning of 1864 up to the time of his death.

It would be impossible within the limits of such a notice as this to give anything like a detailed account of the services to science of this great astronomer. The bare enumeration of the titles of his many valuable papers would exceed them, and in fact such a notice of his work is not necessary here. The name of no one of the great astronomers of this century is more familiarly known in America than that of Encke, and his published labors have instructed astronomers in all parts of the world. They may be found, for the beginning of his career, in Lach's Correspondence and Lindenau's *Zeitschrift*, and, later, in the supplement to the Berlin *Jahrbuch*, in the Memoirs and Monthly Reports of the Berlin Academy, in the *Astronomische Nachrichten*, and in the volumes of the Berlin Observations.

It may be that Encke has contributed most to the advancement of his favorite science in Europe by the improvements that he introduced into the Berlin Ephemeris, by the character that he impressed on the Berlin Observatory, and by the pupils that he trained during his forty

years' professorship, who have had a large share in aiding the progress of astronomical knowledge. But astronomy in America is most indebted to him for his papers on the Method of Least Squares, and on the Computations of Special Perturbations. The Method of Least Squares, which originated with Legendre and Gauss, was systematically and successfully applied in Encke's earlier investigations upon the motions of the comet which bears his name, and its inestimable practical value illustrated. His papers on the subject, together with the numerous examples which his applications of it furnish, have placed the method easily within reach of the student, and have enabled many a young mathematician, with no other aid, to proceed with confidence and success in computations which could never have been undertaken otherwise without the instructions of a master. So admirable have been his arrangements of these difficult computations, and so explicit his instructions upon every part of the work, that it may be truly said that the greater part of what has been done since by astronomers anywhere in the correction of orbits of comets or minor planets, or the computation of their perturbations, has been done under Encke's direction. It was in such work as this that he excelled; and while he showed no want of ability to take the highest rank in any department of theoretical or practical astronomy, it was as a computist that he was pre-eminent.

Sir John William Lubbock, Baronet, was born March 26, 1803; educated first at Westminster School, then at Trinity College, Cambridge, taking the Bachelor's degree in 1825, the Master's in 1833; was admitted to the Royal Society (of which he was a Vice-President at the time of his death) in 1829; married in 1833; succeeded to the baronetcy in 1840, on the death of his father, the eminent banker, Sir John Lubbock; and transmitted the title to his eldest son, John, — also of scientific eminence, — by his death at High Elms, Kent, June 20, 1865. Between the time of reading his memoir on the determination of the orbits of comets before the Royal Society in 1829 and the year 1849, he contributed more than forty papers to the Transactions of that body and of other learned societies, on the moon and the tides, the perturbations of planets, the orbits of comets, and other matters of astronomy, terrestrial physics, and pure mathematics.

He holds a conspicuous place among those who have contributed to the perfection of the Lunar Theory. His claims are thus stated by himself in the Transactions of the Royal Astronomical Society for 1860: "I am confident that a just posterity will give to us [that is, to Plana,

Ponticoulant, and Lubbock, who, in 1846, furnished the means of constructing tables of the moon without any empirical hypothesis] the credit of first bringing the Lunar Tables within the limits of error of observation, and thereby of bringing to perfection the solution of the problem of finding the longitude at sea by means of lunar observations." Of the excellence of the work here referred to, Sir J. Lubbock appears to have first been made aware by its near agreement with the formula from which the American Tables of the Moon were constructed, and the very close agreement of these tables with observation.

Sir William Rowan Hamilton, Astronomer Royal for Ireland, son of Archibald Hamilton, Esq., of Dublin, was born in that city, August 5, 1805, and early put under the tuition of his uncle, Rev. James Hamilton, curate of Trim, by whom his remarkable taste and ability for learning languages were so much fostered, that by the age of fourteen he had made great progress in thirteen languages besides his own, in which he also showed the finest rhetorical powers. His taste for mathematics (perhaps derived from his mother, whose maiden name was Sarah Hutton, and who was of the family distinguished in that science) was so strong that it led him, with very little aid from tutors, to rapid self-directed progress. He began geometry at the age of ten, algebra at twelve; at seventeen he had thoroughly mastered the calculus, and at nineteen, while an undergraduate at Dublin, laid the foundations of a new science; at the age of twenty-two, not yet having taken his Bachelor's degree, he was made Andrews Professor of Astronomy in his own University; not because he was an astronomer, nor because his *Alma Mater* wished him to become an astronomer; but because she wisely wished to secure the residence of a son of such rare genius and virtue. His mathematical writings consist of a single volume, Lectures on Quaternions, published in 1853, and of numerous contributions to the Transactions of the Royal Irish Academy, from 1828 to 1847; to the Philosophical Magazine, from 1831 to 1861; and to the first four volumes of the Cambridge and Dublin Mathematical Journal. These contributions all relate to pure Mathematics or to Analytical Mechanics, — his wealth of metaphysical, poetical, and philological learning and ability never luring him from his chosen walk, — and all show a master's hand.

His papers on Optics were the first example of extended investigations into the phenomena of motion abstracted from the idea of force; and his prediction of conical refraction, having been verified by subse-

quent observation, has in it the same sort of moral sublimity as that which attaches to the discovery of Neptune in consequence of Le Verrier's predictions. Led by a remarkable expression of Kant to endeavor to develop the science of pure Time, Hamilton succeeded, first in giving a new and better interpretation to algebra, and afterwards in inventing, or as he modestly says discovering, a quaternion notation for Space, having a generality that enables one to express in a brief equation truths that previously required a volume. We live too near the time of its origin to comprehend its value; but a notation capable of such condensation of expression should be an engine of incalculable power. This Science of Quaternions, first given to the Royal Irish Academy in November, 1843, and published in the Philosophical Magazine in July, 1844, has four kinds of symbols, one for real quantities, and three for imaginary.

In private life he was admired and loved; the highly poetical imagination which was at the foundation of his geometrical ability showed itself constantly in his conversation. His impulsive, ardent temperament never led him into controversy, but his regard for the rights, the opinions, and wishes of other persons was continually manifesting itself in thoughtful courtesies and kindnesses. He made pure mathematics his study, and metaphysics a favorite relaxation, reaching heights of speculation in both to which few attain; but he held with devout simplicity to that Christian faith which was the guide and joy of his life. He died September 2, 1865.

The Rev. WILLIAM WHEWELL, D. D., was born at Lancaster, May 24, 1794, and died at the Lodge, Trinity College, Cambridge, March 5, 1866, in consequence of being thrown from his horse some days before. He took the Bachelor's degree at Trinity College in 1816, obtained a Fellowship, was a Tutor for some years, and was appointed to a Professorship of Mineralogy in 1828, holding that office four years, when he resigned. In 1838 he was made Professor of Moral Theology, and resigned the chair in 1855, when he became Vice-Chancellor of the University. He was also appointed Master of Trinity College in 1841, and held that high position at the time of his death.

Dr. Whewell was a man of great and varied learning, handling with ability the most diverse subjects of inquiry; beginning with Reports to the British Association on the Tides, and on the Mathematical Theories of Heat, Magnetism, and Electricity, and with the Bridgewater Treatise on Astronomy, and text-books on Elementary Mechanics;

then proceeding to a History of the Inductive Sciences, and a Philosophy of the same, afterward called a History of Scientific Ideas; passing thence to the editing of Mackintosh's Introduction to Ethical Philosophy, to volumes of his own upon Morals, and to translations from Plato's Ethical Dialogues; then to the editing of Richard Jones on Political Economy, and a volume of his own upon that subject, and finally amusing himself with Notes on the Architecture of Churches in France and Germany, writing English Hexameters, and an anonymous book on the Plurality of Worlds.

Dr. Whewell undoubtedly exercised a large influence on public education in England, especially in commending the physical sciences, and giving them an honorable place in the University at Cambridge. His style was singularly clear, and his views of every subject comprehensive, if not marked by peculiar originality. His attachment to the College in which he was educated was earnest, and showed itself not only in his pertinacious resistance of every claim or pretension on the part of others which he thought inconsistent with her dignity, even when claiming rights in behalf of the Crown; but also by his munificent gift of a large hostel for her students, and of an endowment for its support and enlargement.

The names of HOOKER and LINDLEY, which stood side by side in our botanical section, are naturally associated as those of the two most eminent botanists in Great Britain, — also by the parallel course, and near coincidence in the close, of their lives. Born in the same neighborhood, in youth receiving their education at the same school, and early drawn together by similar predilections, they both devoted themselves with singular energy and perseverance to their chosen pursuit; exerted for many years, although in somewhat different ways, a paramount influence upon the advancement of botanical science; and died near together in place and time, — the elder at Kew, on the 12th of August last, at the age of eighty-one years; the younger at Turnham Green, on the first of the ensuing November, at the age of sixty-six years. For a long time they were the two most distinguished teachers in Great Britain, one at a northern, the other at the metropolitan University. They severally conducted two of the principal serial works by which botany contributes to floriculture; and they developed into highest usefulness those two great establishments, the Royal Gardens at Kew, and the Horticultural Society of London. Both wrote and published largely; — Hooker only upon descriptive botany, in which he

greatly excelled, while Lindley traversed a wider field, and grappled with abstruser problems in every department of the science, always with confidence and facility, but not with unvarying success.

William Jackson Hooker was born on the 6th of July, 1785, at Norwich, where resided Sir James Edward Smith, the possessor of the Linnæan herbarium, and a leading botanist of the time. It was he, probably, who directed young Hooker's attention to botany; but his fondness for natural history, especially for ornithology, was already developed in the school-boy. Going up to London as a young man, he made the acquaintance of Sir Joseph Banks and of the able botanists he had drawn around him; in the year 1809 he went to Iceland; on his return from a successful exploration, the vessel in which he had embarked with all his collections, notes, and drawings, was fired and everything was lost, save the lives of the crew and passengers. In 1811 he published his earliest work, the "Journal of a Tour in Iceland"; before 1820, he had brought out his monograph of the *British Jungermanniea*, and the *Muscologia Britannica*, both illustrated by his own pencil. From 1820 to 1840 he filled, with distinguished success, the chair of the Regius Professorship of Botany at the University of Glasgow; and he brought out, during these twenty most active years, the greater part of his extensive writings upon Phænogamous Botany, among which we should especially notice his *Flora Boreali-Americana*, or Botany of British America, founded on the collections of the Arctic explorers, and of his correspondents in Canada and Western North America, including what is now Oregon and Washington Territory.

In the year 1841, when it was determined that the gardens and plant-houses at Kew, then crown domain, should be converted into a great national establishment, Doctor, now Sir William Hooker, was naturally looked to as the proper person to take charge of it. He accepted the trust, and, generously supported by the government under every administration, he devoted his energies and rare talents for organization to the creation and development of the conservatories, museums, gardens, and plantations, stocked with the vegetable productions of all lands, which (including also the vast and unrivalled herbarium that he had himself amassed) have, within the short space of a quarter of a century, made Kew the botanical metropolis of the world.

All this he did without much abatement of his activity in botanical investigation and authorship; although of late years restricting his proper studies very much to the Ferns. His most comprehensive work

upon this great order, the *Species Filicum*, was completed only two years ago; when the indefatigable author, upon the verge of fourscore, immediately and courageously entered upon the preparation of a condensed Synopsis of all known Ferns, and had made considerable progress in the undertaking, when the attack of a prevalent epidemic suddenly closed his long, honored, and most useful life.

Sir William Hooker was doubtless the most prolific botanist of the age, even exceeding Linnæus in this respect, — having published about seventy volumes (including the journals he edited) and over four thousand plates, all the earlier ones from his own drawings, and having described as many new species as there were of plants known in the time of Linnæus. This is not so extraordinary when we consider that his term of authorship covers fifty-five years, no part of which was unproductive, and that his opportunities were unusually great, through his numerous pupils and distant correspondents, — inspired by his zeal and attached by his generosity and winning ways, — who sent him the vegetable productions of all lands; as also by his public spirit and influence with men in office, through which governmental facilities were secured, and botanists appointed when possible to all exploring expeditions and voyages. His opportunities, therefore, were of his own making, and were improved by a sustained industry and single devotion to his pursuit, that have never been surpassed. Like Linnæus also, but unlike most naturalists, so well had he calculated his powers and directed his aims, that he left no half-finished works behind him, but completed everything he undertook, excepting that upon which he had just entered when he was called to his rest. Mere amount of publication in descriptive botany may be of small or equivocal merit. Of Hooker it is to be remarked, not only that he did a vast amount of botanical work, but that he did it surpassingly well.

John Lindley was born at Catton, near Norwich, on the 5th of February, 1799, and was educated at the grammar school of that town. His father was a nurseryman of some consideration, and the author of a well-known work upon the orchard and kitchen garden. Young Lindley's bent for natural history was congenital, and his special vocation, as the practical illustrator and introducer of the natural system into common use wherever the English language is spoken, was early indicated. In one of his first lectures, a sketch of which has just been printed from his manuscript, he gave a lively account of his early endeavors after botanical knowledge, and the small satisfaction that

rewarded them; of the kind notice that was taken of him by Sir James Edward Smith, the head of the prevailing school, and the maintainer of the full sufficiency of the Linnæan artificial system, who, by cautioning the young man not to be led astray by new and false lights, first awoke a curiosity which began to be gratified when he soon afterwards visited his friend Hooker, and was by him introduced to Jussieu's *Genera Plantarum*, and Richard's *Analyse du Fruit*. It was then, as he says, that his botanical life commenced, and a translation from the French of Richard which he made on the spot, at one sitting of three days and two nights, was the first of his numerous publications. In 1818 or 1819, he went up to London, and, introduced by Hooker to Sir Joseph Banks, was employed by him for a time as assistant librarian. Sir Joseph introduced Lindley to Mr. Cattley, a wealthy merchant and amateur cultivator, who wanted scientific assistance in illustrating and publishing some new plants of his collection. In this service, Lindley in 1821 brought out the fine folio volume entitled *Collectanea Botanica*. He dedicated it to Mr. Sabine, the Honorary Secretary of the Horticultural Society of London, under whom the next year he became Assistant Secretary, just when the famous garden at Chiswick was to be laid out. In 1826, as sole Assistant Secretary, and afterwards as Vice Secretary, Lindley became, and long remained the practical head of this important establishment, which, under his wise and energetic administration, has rendered vast service to horticulture and to botany. From the year 1829 to 1861 he was Professor of Botany in the London University, and at the same time lecturer at the Apothecaries' Garden at Chelsea. In 1830, he published the first edition of his Introduction to the Natural System of Botany, revised and amplified it in 1836, and in 1846 he expanded it into that encyclopædia of botanical knowledge, "The Vegetable Kingdom, or the Structure, Classification, and Uses of Plants, illustrated upon the Natural System." The several works upon structural and physiological botany, which accompanied the systematic ones already mentioned, those upon medical and economical botany, his Theory and Practice of Horticulture, and the like, need not here be enumerated, being among the best known and most widely used botanical books of the age. The same may be said of Loudon's Encyclopædia of Plants, the scientific part of which was by Lindley, and of the Botanical Register, the rival of the Botanical Magazine, which he edited for about twenty years. He originated, in 1841, the Gardeners' Chronicle, and conducted it

until recently, when his health gave way. Of his various labors and writings relating to horticulture, it has been said to be mainly due to them "that this branch of knowledge has risen from the condition of an empirical art to that of a developed science." At least it may be asserted that scientific horticulture in Great Britain owes more to Lindley than to any other person, except, perhaps, to his predecessor, Knight. In systematic botany his most considerable and profound works related to orchideous plants, upon which he has long been the paramount authority. Physiologist, morphologist, and systematic botanist, he displayed equal genius in all these departments of the science; and, if he worked too rapidly to do full justice to his great powers in any one of them, he must be allowed to have contributed efficiently to the advancement of them all.

His distinguished scientific career was cut short in the year 1862, by an affection of the brain, brought on by protracted and severe overwork; and he died of apoplexy on the first of November last, leaving a void not easy to be filled.

Louis Isidore Duperrey, Admiral in the French Navy, was born in Paris, October 22, 1786. He entered the Navy in 1802, and was for a long time in active service. In 1811 he executed a hydrographic survey of the coast of Tuscany. In the French expedition of 1817, for determining the figure of the globe and the elements of terrestrial magnetism and other purposes, he was entrusted with the hydrographical operations. Soon after this, in 1822, he was placed in command of a new expedition around the world for scientific discovery. An account of this voyage was published in Paris, in six quarto volumes, in the years 1828 – 32. His observations on the invariable pendulum, and on the inclination and declination of the magnetic needle, made in this voyage, were published in 1827. He also published papers on the configuration of the magnetic equator in 1830; on the direction and intensity of terrestrial magnetism in 1837, and in 1841, a paper upon the geographical positions of the magnetic poles, and especially on the position of the southern magnetic pole. He died in Paris, after a long illness, on the 25th of August, 1865.

Twenty-two members have been elected into the Academy during the year. Nine of these are Resident Fellows, two of the first class, two of the second, and five of the third class.

Nine are on the Associate or Non-resident list, two in the first, two in the second, and five in the third class.

Four are Foreign Honorary Members, viz.: J. Victor Poncelet of

Paris, in the Fourth Section of the First Class, to fill the vacancy caused by the death of Wilhelm Struve of the Astronomical Section; Arthur Cayley of London, in the Mathematical Section of Class I., in the place of the late Sir Wm. Rowan Hamilton; M. Delauney of Paris, in place of the late Sir John Lubbock of the same Class and Section; and Dr. Joseph Dalton Hooker, of Kew, in place of his father, the late Sir William Jackson Hooker, of the Second Class and the Botanical Section.

Professor Lovering, as Chairman of the Committee of Publication, presented a report accounting for the expenditures in printing under the appropriations of the past year. The report was accepted.

Professor Cooke presented the report of the Library Committee; which was accepted.

Mr. Paine reported that he had received from the representatives of the late Jonathan P. Hall the thermometer belonging to the Academy, and the records of Mr. Hall's observations.

Mr. Paine was authorized to obtain the barometer of the Academy used by Mr. Hall, and to get it repaired.

Remarks were made by the President and by the Librarian on the aid rendered by the Smithsonian Institution in effecting the exchanges of the Academy; and on the motion of the Librarian it was

Voted, That the thanks of the Academy be presented to the Smithsonian Institution for the generous and efficient aid which it has rendered through its system of foreign exchanges and distribution of publications, by which the Academy has greatly profited.

The President announced from the Finance Committee that the unexpended balances of past appropriations were not included in the appropriations recommended for the current year. In accordance with information from Professor Eliot concerning a sum of money raised by subscription for the general expenses of the Academy, the recommendations of the Finance Committee were amended, and the following appropriations passed: —

For General Expenses	$1,400
For the Library	1,000
For Publication	1,000

The election resulted in the choice of the following officers for the ensuing year: —

Asa Gray, *President.*
George T. Bigelow, *Vice-President.*
William B. Rogers, *Corresponding Secretary.*
Chauncey Wright, *Recording Secretary.*
John C. Lee, *Treasurer.*
Frank H. Storer, *Librarian.*

Council.

Thomas Hill,
Joseph Lovering,
John B. Henck, — of Class I.

Augustus A. Gould,
Louis Agassiz,
Jeffries Wyman, — of Class II.

Robert C. Winthrop,
George E. Ellis,
Andrew P. Peabody, — of Class III.

Rumford Committee.

Joseph Lovering, Joseph Winlock,
Morrill Wyman, Wolcott Gibbs,
William B. Rogers, Frank H. Storer,
Josiah P. Cooke.

Committee of Finance.

Asa Gray,
John C. Lee, — *ex officio*, by statute.
Thomas T. Bouvé, by election.

The other Standing Committees were appointed on the nomination of the President, as follows: —

Committee of Publication.

JOSEPH LOVERING, JEFFRIES WYMAN,
CHARLES W. ELIOT.

Committee on the Library.

JOHN B. HENCK, CHARLES PICKERING,
JOHN BACON.

Committee to audit the Treasurer's Accounts.

CHARLES E. WARE, CHARLES J. SPRAGUE.

The following gentlemen were elected members of the Academy: —

Nathaniel Thayer of Boston, to be Resident Fellow in Class III. Section 3.

Professor William P. Atkinson of Cambridge, to be Resident Fellow in Class III. Section 2.

Hon. Horace Gray, Jr. of Boston, to be Resident Fellow in Class III. Section 1.

Stephen P. Ruggles of Boston, to be Resident Fellow in Class I. Section 4.

Professor Noah Porter of Yale College, to be Associate Fellow in Class III. Section 1.

Chief Justice Ira Perley of New Hampshire, to be Associate Fellow in Class III. Section I.

Dr. A. W. Chapman of Appalachicola, to be Associate Fellow in Class II. Section 2.

George Bentham of London, to be Foreign Honorary Member in Class II. Section 2, in place of the late Professor Lindley.

Hervè Auguste Etienne Alban Faye of Paris, to be Foreign Honorary Member in Class I. Section 2, in place of the late M. Encke.

William John Macquorn Rankine to be Foreign Honorary Member, in Class I. Section 4, in place of the late Admiral Smyth.

Five hundred and seventieth Meeting.

June 12, 1866. — ADJOURNED ANNUAL MEETING.

The PRESIDENT in the chair.

Professor Lovering communicated an unanimous recommendation from the Rumford Committee that the following vote be passed, viz.: — That the Rumford Premium be awarded to Alvan Clark of Cambridge, for his improvements in the manufacture of refracting telescopes, as exhibited in his method of local correction.

Professor Lovering described Mr. Clark's methods of testing and polishing lenses, and recounted the grounds of the Committee's recommendation.

The report was accepted, and on motion of Dr. Jacob Bigelow the vote was unanimously passed.

Five hundred and seventy-first Meeting.

September 11, 1866. — MONTHLY MEETING.

The PRESIDENT in the chair.

The President read letters relative to exchanges; also letters from Professor Rankine and M. Faye in acknowledgment of their election into the Academy.

The President called the attention of the Academy to the recent decease of Professor Henry D. Rogers of Glasgow, of the Associate Fellows, formerly a Resident Fellow; also of Dr. Reuben D. Mussey and Mr. James Hayward of the Resident Fellows.

Professor Winlock read the following communication from Professor Daniel Treadwell: —

The force of every moving body, or that attribute by which a moving body overcomes any resistance opposed to it, is the product of two factors, namely, *mass* and *velocity*. There is an old dispute as to the true value of one of these factors, the velocity; but it may, I think, be at the present time confidently assumed that the value assigned to it by Leibnitz, namely, its square, is the true value in this case. Taking

this then to be established, we have a very simple, easy, and direct method of comparing, one with another, the forces of cannon-balls of every possible weight, or rather inertia, as measured by their weight, moving with any velocity that may be impressed upon them. In making this comparison between the forces of the balls used, especially in the most powerful of the vaunted American and English cannon of modern construction, it will be necessary first to establish some standard which may be used as the unit of measure, with which the others are severally compared and tried. To do this I shall take the ball of the old 32-pounder under a velocity of 1,600 feet a second, this being a mass and velocity with which all artillerists are familiar, being that produced by eight pounds of powder, the full charge of this gun; and I shall use the force possessed by this ball under these conditions as the standard, or unit of the standard, by which the force of any others may be compared or measured.

It is very desirable that the unit of every standard of measure should be taken from some simple and familiar object, of the quantity of which we can not only form a conception, but with which we have a familiar sensible acquaintance. Our common standards of weight and measure have been thus derived, the grain of wheat forming the unit of one, and the human arm and foot that of the other. In the more complex instance of the power of the steam-engine, the strength of the horse furnishes the basis of the standard of measure, and this again is defined in a certain number of pounds raised one foot high against the opposing force of gravitation. It will be at once perceived that, although a 32-pound shot moving with a velocity of 1,600 feet a second may form some image capable of being grasped by the conception, yet we must utterly fail to form a distinct idea of the quantity represented by 32 multiplied by the *square* of 1,600, or of the algebraic symbols $m v^2$, representing the product of a mass by the square of a velocity. It will be seen, however, that we may bring the proposed standard of comparison out of this dark envelope, by changing the factor of the velocity into a physical equivalent taken in a vertical line a certain number of feet high. Thus, instead of saying that the force of a 32-pound shot under a velocity of 1,600 feet a second is numerically represented by $32 \times 2{,}560{,}000$, we may substitute for this last factor the height to which the shot would rise if it were pointed directly upwards *in vacuo*, so that it should be freed from every atmospheric and other resistance except that of gravitation alone. To do this we

have only to calculate the height to which a body will rise under the given conditions, and for which we have a very simple formula, —

$\frac{v^2}{2g} = h$, in which v is the velocity of the shot, g the velocity acquired by a body falling one second, and h the height sought;

and we then have our standard unit in pounds raised to a known height. In the case before us we shall find the height to be 40,000 feet; and if we multiply this by the weight of the ball or shot, 32 pounds, we have a product of 1,280,000, or 1,280,000 pounds raised one foot high, as the equivalent of the force of a 32-pound shot moving with a velocity of 1,600 feet a second. We can have no difficulty in forming a conception of this amount of force, or power, and applying it as a measure of the force of shot of other weights moving with other velocities. We may, in fact, compare it with the force of a steam engine, reducing both to a common measure in the horse power. Thus, the horse power being 33,000 pounds one foot high in one minute, we have $\frac{1280000}{33000} = 39$; or the 32-pound shot, when it leaves the mouth of its cannon, equal to the work of 39 horses during one minute of time.

Although we may, by this method ascertain, with great exactness, the comparative forces and, consequently, value, of different shot, it requires yet another step of computation to enable us to compare together the value of different guns; to ascertain their relative strength, whether it be derived from the different materials of which they are made, or the peculiar mode or form of their construction. Thus, suppose it to be determined by accurate experiment that a certain ball from a cast-iron Rodman gun has the same force that is possessed by a ball from a wrought-iron coil gun. This fact can give no warrant to the inference that the cast iron is equal in strength to wrought iron, or that a certain method of casting produces a gun of equal value and efficiency to guns made of forged coils. It may be, and must be in this case, that a much greater weight of the inferior metal is required to produce the strength supplied by a smaller amount of the better metal.

To supply the deficiency of the computation thus pointed out, and extend the proposed standard so as to become a measure of the strength of the gun as well as of the force of the shot, we shall find to require but a moment's attention. Having already seen that our standard 32-pound shot has a force of 1,280,000 pounds one

foot high ($32 \times 40,000$), if we divide this product, representing the strength of the whole gun, by the weight of the metal of which the gun is made up in pounds, we shall obtain the strength, or work which may be done by each pound of which the gun is constituted. We shall find the result of this computation (the weight of our standard 32-pounder being 7,500 pounds) to be ($\frac{1280000}{7500} = 171$) 171 pounds, in shot, raised one foot high by every pound of metal which forms the body of our standard gun.

By this form of computation we may compare, numerically, the strength of one gun with another, and assign to each the true value derived from its peculiar metal, or the method employed in its construction, free from all adventitious strength that may be supplied by a mere increase of mass or quantity of material. The accuracy of the result will of course depend upon the experimental determination of the weight of the shot and the velocity which the gun may be relied upon to enable us actually to produce and practise, without exceeding the limits of the strength of the gun.

Dahlgren.

I now proceed to the application of these forms of computation to the guns now most relied upon in the American and English service. First the cast-iron ten-inch gun known in this country as the ten-inch Columbiad, and described as follows: —

Diameter of bore,	10 inches.
Weight of gun,	15,059 pounds.
Weight of shot,	128 "
Charge of powder,	18 "
Initial velocity of shot,	1,044 feet.

From these several elements the following results are obtained by the mode of computation before pointed out.

Height to which the shot will rise if pointed directly upward, *in vacuo*, 17,030 feet.

Force in pounds raised one foot high, 2,179,840.

Force compared with the 32-pound shot under a velocity of 1,600 feet a second, this being taken as 1, 1.7.

Force in number of horses working one minute of time, 66.2.

Number of pounds (in shot) raised one foot high, by each pound in the weight of the gun, 144.7.

Rodman.

Passing from this to the giant of the service, the Rodman fifteen-inch gun, which gives the following elements to be subjected to computation: —

Diameter of calibre,	15 inches.
Weight of gun,	49,099 pounds.
Weight of shell,	315 "
Charge of powder,	50 "
Initial velocity of shot,	1,118 feet.

From which we obtain: —

Height to which the shot will rise *in vacuo*, 19,530 feet.

Force in pounds raised one foot high, 6,051,950.

Force compared with the 32-pound shot under a velocity of 1,600 feet a second, this being taken as 1, 4.80.

Force in number of horses working one minute, 186.4.

Number of pounds (in shot) raised one foot high by each pound in the weight of the gun, 125.

Next let us examine the 300-pounder coil gun, as constructed by Sir William Armstrong. This is described as follows: —

Diameter of calibre,	10¼ inches.
Weight of gun,	26,880 pounds.
Weight of shot,	300 "
Weight of charge,	60 "
Initial velocity of the shot,	1,500 feet.

From which we obtain the following: —

Height to which the shot will rise if fired *in vacuo* directly upwards, 35,156 feet.

Force in pounds raised one foot high, 10,546,800.

Force compared with a 32-pound shot, being taken as 1, 8.24.

Force in number of horses working one minute, 319.

Number of pounds raised one foot high (in shot) for each pound of metal in the gun, 392.

The last gun that I propose to examine is the Armstrong coil gun, throwing a 600-pound shot. Described as follows: —

Diameter of calibre,	13¼ inches.
Weight of gun,	49,280 pounds.
Weight of shot,	600 "
Charge of powder,	100 "
Initial velocity,	1,400 feet.

These elements give the following results: —

Height to which the shot will rise, if fired *in vacuo*, 30,625 feet.

Force in pounds raised one foot, 18,375,000.

Force, a 32-pound shot taken as 1, 14.35.

Force in number of horses one minute, 556.8.

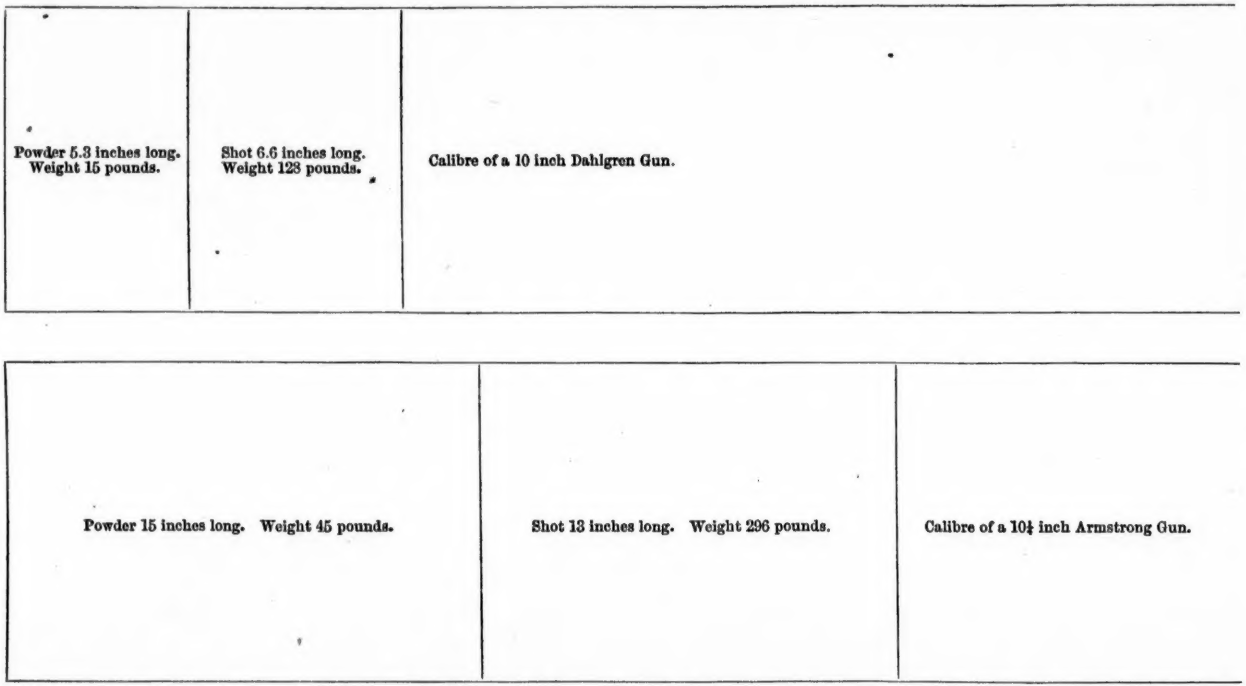
Number of pounds raised one foot high (in shot) by each pound of metal in the gun, 372.8.

The foregoing facts are comprised in the following table: —

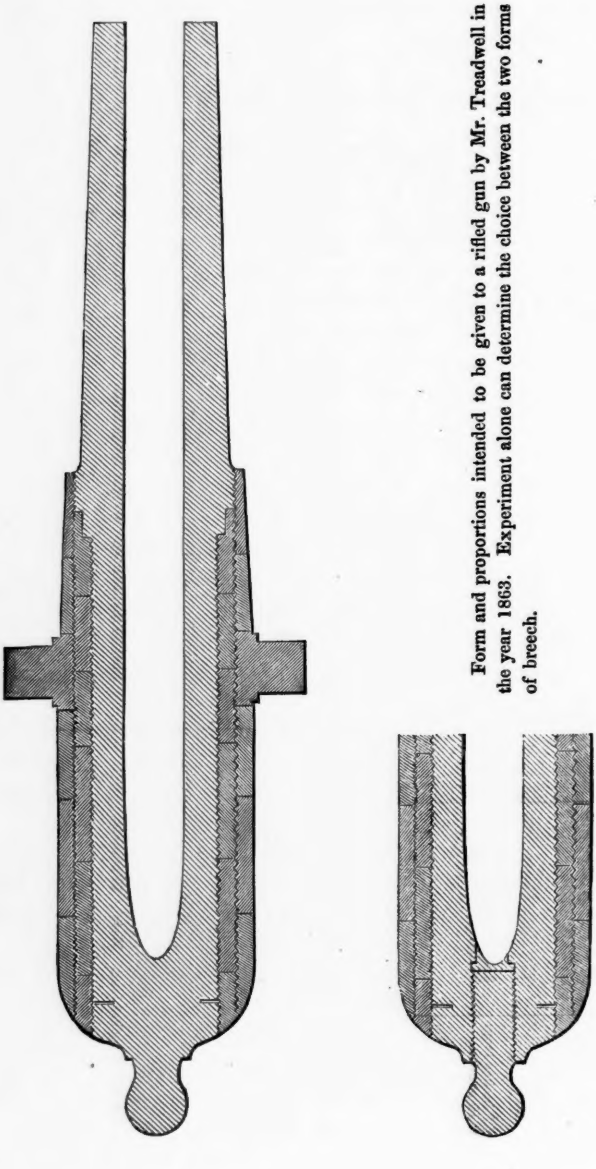
1. Description, or Kind of Gun.	2. Weight of Gun.	3. Weight of Shot.	4. Weight of Powder.	5. Initial Velocity of Shot.	6. Height to which the Shot would ascend if fired upwards *in vacuo*.
	lbs.	lbs.	lbs.	ft.	
Old 32 Pounder	7,500	32	8	1,600	40,000
10 Inch Columbiad	15,059	128	18	1,044	17,030
15 Inch Rodman	49,099	315	50	1,118	19,530
300 Pounder Armstrong . . .	26,880	300	60	1,500	35,156
600 Pounder Armstrong . . .	49,280	600	100	1,400	30,625

1. Description, or Kind of Gun.	7. Force in Pounds raised 1 Foot.	8. Force compared with a 32-lb. Shot under a Velocity of 1,600 ft. a Second (as Unity).	9. Force in number of Horses working 1 Minute.	10. Number of Pounds of Shot raised 1 Foot by each Pound of Metal in the Gun.
Old 32 Pounder	1,280,000	1.00	39.0	170.7
10 Inch Columbiad.	2,179,840	1.69	66.0	144.7
15 Inch Rodman	6,151,950	4.73	186.4	125.3
300 Pounder Armstrong . . .	10,546,800	8.24	319.6	392.4
600 Pounder Armstrong . . .	18,375,000	14.35	556.8	372.8

It should be borne in mind that the increase of resistance occasioned by rifling is not taken into the account, although it makes an important item against the Armstrong guns.



These figures exhibit (in a sensible form) the calibres, and the lengths of the charges of powder, as given in the preceding table, and used in the Columbiad and Armstrong guns respectively.



Form and proportions intended to be given to a rifled gun by Mr. Treadwell in the year 1863. Experiment alone can determine the choice between the two forms of breech.

The President communicated, by title, the following paper, with some remarks upon Mr. Mann's botanical explorations in the Sandwich Islands.

Enumeration of Hawaian Plants. By HORACE MANN.

During a visit to the Hawaian Islands, made for the purpose of studying especially the Botany of the Group, and which extended from the 4th of May, 1864, to the 18th of May, 1865, I botanized over five of the largest of these islands, and brought together a collection which forms the basis of the following *Enumeration.* In its preparation I have been permitted to examine the other collections of Hawaian plants in the Gray Herbarium; namely, that by the United States South Pacific Exploring Expedition under Commodore Wilkes, — the fullest hitherto made in these islands; a set of the specimens gathered by Jules Remy under the auspices of the Paris Museum, given by that institution; some of Macrae's plants, given by the London Horticultural (now Royal Horticultural) Society; and a few of Gaudichaud's, Chamisso's, Douglas's, and Nuttall's. These materials, and all his own memoranda upon them, were freely offered to my use by Professor Gray, without whose friendly encouragement this enumeration would never have been undertaken, and could not have been accomplished.

The botanists who have collected at the Hawaian Islands, so far as known to me, are as follows: —

DAVID NELSON, who accompanied Captain Cook on his third voyage, and collected at the Islands in 1778–1779. The plants collected by him are stored at the British Museum, and, excepting a few *Labiatæ*, have scarcely been examined until recently.

ARCHIBALD MENZIES, a most indefatigable botanist and collector, visited the Islands with Vancouver in 1792, 1793, or 1794, or perhaps in each of these years, and made large and valuable collections, mostly on Hawaii. Sets of his plants are in the Hookerian, Smithian, and Banksian Herbaria.

ALBERT CHAMISSO accompanied Kotzebue in the voyage of Romanzoff, and collected principally on Oahu, late in each of the years 1816 and 1817. He published notes and descriptions of new species in the *Linnæa,* in conjunction with Schlechtendal. FREDERICK ESCHSCHOLTZ was the physician of the expedition.

CHARLES GAUDICHAUD, as botanist of the expedition under Freycinet, in the Corvettes "Uranie" and "Physicienne," visited the Islands in August, 1819. He returned to the Islands on the "Bonite" in 1836. The results of his first expedition were published as the *Botanique du Voyage de l'Uranie*, in 1826 (as on title-page, but really not appearing till 1830), in 1 vol. 4to, with a folio atlas. Of the collections of the second visit a few plates of Hawaiian plants appeared in a folio atlas (*Bot. Voy. Bonite*, bearing no date), without descriptions, or any clew to localities. The lower Cryptogams were elaborated and in part figured by the late Dr. Montagne in the same work.

JAMES MACRAE collected for the London Horticultural Society, in Brazil, Chili, and the Hawaiian Islands, which last he visited in 1825. His specimens were mainly distributed to the herbaria of Bentham, Hooker, Lindley, and De Candolle.

MESSRS. LAY & COLLIE, who accompanied Captain Beechey during the Voyage of the "Blossom," visited the Islands in 1826 – 1827, and made the collections which formed the basis of the botany of this voyage by Hooker and Arnott.

FRANCIS JULIUS FERDINAND MEYEN accompanied Captain W. Wendt, on the Prussian vessel "Princess Louise," and visited these islands in 1831. After his death, descriptions of species collected by him were published as a volume of the Nov. Act. Acad. Cæs. Leop.-Carol. Nat. Cur., in 1843, here cited as the *Reliquiæ Meyenianæ*.

DAVID DOUGLAS, as collector sent out by the London Horticultural Society to N. W. America, closed his most important explorations by a visit to the Hawaiian Islands, which he reached in the last week in the year 1833. He immediately went to Hawaii, where he collected until the 12th of May, when he met a violent death on the flanks of Mauna Kea. His collections are mainly in the herbaria of the Royal Horticultural Society, and of Hooker, Bentham, and Lindley.

BARCLAY was botanist on the "Sulphur," commanded by Sir Edward Belcher, and visited the Islands in 1837 or 1839.

Rev. JOHN DIELL was American Seaman's Chaplain at Honolulu, and sent small collections to Prof. Asa Gray, which he communicated to Sir W. J. Hooker.

W. D. BRACKENRIDGE and CHARLES PICKERING made almost all the botanical collections on the United States South Pacific Exploring Expedition, under command of Charles Wilkes, at least those at the

Hawaiian Islands, which were visited in 1840. The Polypetalæ were published in full in the Botany of the Expedition by Gray, who has also published new species of Monopetalæ in Vols. IV., V., and VI. of the Proceedings of this Academy. But few of the Apetalæ have yet been noticed. The Ferns, by Brackenridge, were published as a separate volume of the Botany of the Expedition; but nearly the whole of the edition was destroyed by fire. Another partially published volume comprises the Mosses by Sullivant, the Lichens by Tuckerman, and the Algæ by the late Professors Bailey and Harvey.

NUTTALL visited the Islands in 1835, from the Northwest Coast, and made a small collection. Most of his specimens are in the Hookerian Herbarium; a few probably in that of the Philadelphia Academy. He published notes and descriptions of some Hawaiian *Compositæ*, *Lobeliaceæ*, and *Vaccinieæ* in the Transactions of the American Philosophical Society.

JULES REMY went to the Islands under the auspices of the Paris Museum, and made a fine collection in the years 1851 – 1855.

WM. HILLEBRAND, a physician resident in Honolulu, has recently sent interesting collections to Kew, among them a new genus of *Begoniaceæ*, which Prof. Oliver has named after its discoverer.

W. T. BRIGHAM, with whom I visited the Islands, aided me constantly in collecting, and remained five months after my return, obtaining several species not in my own collection.

The Hawaiian Islands lie just within the northern tropic, between 18° 55′ and 22° 20′ N., and 154° 50′ and 160° 40′ W. Their climate is not extreme, being much moderated by the N. E. trade winds, which blow pretty steadily for three fourths of the year. The mean annual temperature at Honolulu is about 79° Fahr.; that of the summer, or from May to October, about 81°, and that of the remaining half-year, or winter months, about 75°; the thermometer ranging mostly between 60° and 86°. Lahaina, under the lee of the mountain of West Maui, and Waimea, in the same relative position to the mountain of Kauai, are the two hottest places, while on the summits of the highest mountains the snow persists through nearly the whole year. The snow descends on the flanks of the high mountains to a level of 6,000 or 7,000 feet above the sea, at least in cold winters, but never lies at that elevation long, quickly retreating upward with the return of a warm day.

The group comprises thirteen islands, only seven of which, however, are of any considerable size. These extend in a curved line from E. S. E. to W. N. W., about 600 miles in length. Their superficial area is about 6,500 square miles; the largest island, which is also the most easterly one, *Hawaii*, being about 100 miles long, by 80 or 90 miles wide, of an irregular oval shape. It also presents the highest mountains of the group, as well as of the Pacific, — Mauna Kea being 13,980 feet, and Mauna Loa, 13,760 feet; Hualalai somewhat exceeds 8,000 feet.

The next island to the west, *Maui*, is the next in size also. It consists in fact of two islands, joined by a low sandy isthmus, so low that more than one vessel has been wrecked by attempting to pass between them, mistaking the gap for the Molokai Passage, next westward. The eastern end of Maui is composed of the mountain Haleakala, somewhat exceeding 10,000 feet in height. West Maui is about 6,500 feet high; its mountain is known as Eeka; several of its highest portions also bear distinctive appellations.

Molokai lies next to the westward, but is the fifth in size. The highest point is near the eastern end, and perhaps reaches 3,500 feet.

Lanai lies a few miles S. S. W. from West Maui, and is the sixth in size. It probably does not exceed 2,500 feet in height.

Oahu, west of Molokai, is the fourth in size. Its mountains are two somewhat parallel ridges of unequal length, lying nearly east and west, the northern one twice the length of the southern. The northern ridge is partly divided by Nuuanu Valley, the mountains to the east taking the name of their highest peak, Konahuanui; those to the west, the name of Waiolani, the highest peak on that side. Each of these peaks probably a little exceeds 4,000 feet. The farther western end of this range (sometimes called the Waialua Mountains) spreads out to a very considerable breadth, and is extremely difficult of access, so much so that it is probable no white man has ever been to the heart of the region. The southern ridge is known as the Kaala Mountains.

Kauai, the island next west, is the third in size, consisting in great part of a central mountain, 6,500 or 7,000 feet high, with an extensive plateau on its leeward flank, at the height of from 3,000 to 4,000 feet.

Niihau, the most westerly island (excepting a few mere rocks) lies to the S. W. of Kauai, is the seventh as regards size, is in no part above 2,500 feet, and is destitute of forests.

Returning again to *Hawaii*, where on the whole the climatic condi-

tions are the plainest, and the regions of vegetation best defined, we have an island whose shores are the lower slopes of three mountains, the relative position of which is that of the three angles of a nearly equilateral triangle. These mountains enclose an extensive plateau at an elevation of about 5,000 feet. The windward shores and slopes of Hawaii are the most rainy part of the group, in consequence of the high peaks above, which condense the moisture of the trade winds, and keep it almost continually falling. The elevated plateau is dry, as much on account of its sterility, as it is sterile on account of its dryness; for whatever rain reaches it sinks into the porous lava soil as fast as it falls. The low region is comparatively sterile on account of its being cut off by the high intervening peaks from the reach of the trade winds, and its heat quickly evaporates any thin clouds which may drift over it. The higher leeward regions possess of themselves sufficient coolness to condense the moisture of the air into clouds; and it is owing to the protecting influence of the mountain peaks that the clouds are not blown away by the strong trade winds before they deposit their moisture, as is the case in some places. Thus we have a wet region all along the eastern side of the island, and extending around to the south and to the west, until it reaches the base of Hualalai; and this wet region, between the height of 1,500 or 2,000 feet to about 5,000 feet, is the most heavily wooded of the group. The parts between 1,500 feet and the sea level comprise comparatively few species, and but little of the peculiar vegetation. The high and dry mountain tracts, above 4,000 or 4,500 feet, are very distinct in their character and vegetation from either of the regions below. The highest lava summits are nearly destitute of vegetation.

Similar considerations, making allowances for physical contour, &c., explain the similar distribution of wet and dry regions, and of vegetation, on the other islands. Thus, the summit of Haleakala, above 6,000 feet, has the character and nearly the same plants as the higher parts of Hawaii, and its windward slopes are wet and heavily wooded. The high summit stands in the way of the winds in such a manner as to make an eddy to the leeward, where clouds gather every day, and supply sufficient moisture to sustain a forest, while other parts are more frequently cloudless and drier. The summits of West Maui, Oahu, and Kauai, lying between the heights of 4,000 and 6,500 feet, are just in the cloud level, and, being also peaks where denudation has long been active, the soil has become somewhat impervious to moisture, which

therefore remains on the surface. The region has a peculiar aspect, which is at once recognized in ascending the mountains. The only forest-tree, the ohia lehua (*Metrosideros polymorpha*) becomes stunted; the trunks are covered with a thick coating of *Mosses* and *Hepaticæ*, which retains the moisture so as to render everything dripping wet; and not more than a dozen species of flowering plants and ferns occur in the whole. Above this, on the mountains of West Maui and Kauai, there is an open tract, where the lehua, one of the largest forest-trees, at an elevation of 2,000 feet, has become dwarfed, a foot or two high, in spreading clumps, but still flowering luxuriantly. In the midst of such clumps are found the violets peculiar to these regions, and in the neighboring tussocks of sedge (an *Oreobolus*) are found the few other plants, which occur here and nowhere else, to the number of eight or nine; also *Drosera longifolia*, thousands of miles from its next nearest known habitat.

The lower parts of the Kaala mountains, and the lower parts of the leeward flank of Kauai, have many characteristics in common, both being somewhat deprived of moisture by high land to the windward.

By far the greater portion of the soil has been formed by disintegration of the lava; the thin sandy soil of those parts which consist of raised coral reefs (as some of the shore regions of Oahu), and that which is formed by the drifting inland of the calcareous beach sands, support a few species which are not found elsewhere.

It is the purpose of this enumeration to give as complete a list as possible of the plants indigenous to the group, inserting also the probably introduced plants which have become thoroughly naturalized. Those which are without doubt indigenous have been left unmarked. Those which are probably of aboriginal introduction are marked with an asterisk (*); the few which are in all probability recent introductions, with a dagger (†).

The specimens which have been distributed, under numbers, from the collection of Mr. Brigham and myself, are referred to by the initials M. & B. The numbers of Remy's plants are cited, as far as they have been met with in the Gray Herbarium. Hillebrand's collection is not here represented fully enough to make it worth while ordinarily to cite his numbers.

Ranunculaceæ.

1. Ranunculus Hawaiensis, Gray, Bot. S. Pacif. Expl. Exp. 1, p. 10. (M. & B. 314.)

2. Ranunculus Mauiensis, Gray, l. c. p. 11, & *var. β.* (M. & B. 446; Remy, 920.)

Menispermaceæ.

3. Cocculus Ferrandianus, Gaud. Bot. Voy. Freyc. p. 477, t. 101; Walpers, Rel. Meyen. p. 298. *Nephroica Ferrandiana*, Gray, Bot. S. Pacif. Expl. Exp. 1, p. 39. (M. & B. 110.)

Cruciferæ.

4.† Cardamine hirsuta, Linn.; Gray, Bot. S. Pacif. Expl. Exp. 1, p. 50. (M. & B. 311.)

5. Lepidium Owahiense, Cham. & Schlect. in Linnæa, 1, p. 23; Hook. & Arn. Bot. Beech. Voy. p. 78; Walp. Rel. Meyen. p. 250; Gray, l. c. p. 63. The cotyledons, at least in some seeds, are accumbent. (M. & B. 343, 593; Remy, 523, 524.)

6. Lepidium serra (sp. nov.): fruticosum, fere glabrum; foliis lanceolatis crebre arguteque laciniato-serratis membranaceis ad apicem ramorum confertis inferne in petiolum gracilem longe attenuatis; pedunculis gracillimis folia subsuperantibus racemos breves corymbosos bracteis filiformibus stipatos gerentibus; floribus longe pedicellatis; siliculis junioribus ovato-rhomboideis stylo apiculatis, maturis oblato-orbiculatis, stylo ex emarginatura minima vix exserto; cotyledonibus accumbentibus. — Hanapepe, Kaüai. — A straggling, much branched shrub, 2 – 3 feet high. The young inflorescence is slightly puberulent. The cotyledons are clearly accumbent! (M. & B. 588.)

7.† Senebiera didyma, Pers. Ench. 2, p. 185; Desv. Journ. Bot. 3, p. 164; Gray, l. c. p. 63.

Capparidaceæ.

8. Cleome Sandwicensis, Gray, Bot. S. Pacif. Expl. Exp. 1, p. 65. *Cleome spinosa*, Hook. & Arn. Bot. Beech. Voy. p. 78; Walp. Rel. Meyen. p. 251, non Linn.

9. Capparis Sandwichiana, DC. Prodr. 1, p. 245; Hook. & Arn. Bot. Beech. Voy. p. 59; Gaud. Bot. Voy. Bonite, t. 55; Gray, l. c. p. 69. (M. & B. 108; Remy, 529.)

Violaceæ.

10. VIOLA KAVAIENSIS, Gray, Bot. S. Pacif. Expl. Exp. 1, p. 85.

11. VIOLA MAVIENSIS (sp. nov.): glabra; caudicibus elongatis suffruticosis adsurgentibus stipulis squamaceis ovato-lanceolatis diu persistentibus vestitis apice conferte-foliaceis; foliis rotundatis in petiolos graciles cuneato-decurrentibus adpresse serratis, dentibus glanduliferis; scapis elongatis bibracteatis umbellato-bi-quadrifloris; petalis cæruleis imberbibus sepala lanceolata bis terve superantibus, inferiore latissime saccato. — Top of the mountain of West Maui. — The ascending caudices a foot long, clothed at the summit with densely imbricated ovate-lanceolate acuminate setigerous-dentate stipules. Leaves clustered at the apex of the caudex. Scape 3-8 inches long, bearing two bracts about the middle. Pedicels umbellate from the bracted summit of the scape. Petals dark blue, the lower one very broadly short-saccate. (M. & B. 432.)

12. VIOLA CHAMISSONIANA, Ging. in Linnæa, 1, p. 408; Gray, l. c. p. 86. *V. tracheliifolia*, Ging. l. c. p. 409. (M. & B. 594; Remy, 532.)

13. ISODENDRION PYRIFOLIUM, Gray, Bot. S. Pacif. Expl. Exp. 1, p. 93, t. 8.

14. ISODENDRION LONGIFOLIUM, Gray, l. c. p. 95, t. 9.

15. ISODENDRION LAURIFOLIUM. Gray, l. c. p. 96.

Bixaceæ.

16. XYLOSMA HAWAIENSE, Seem. Fl. Vitiensis, p. 7, adnot. (M. & B. 206; Remy, 536; Hillebrand; Barclay, 1256.)

Pittosporaceæ.

17. PITTOSPORUM CONFERTIFLORUM (Gray, Bot. S. Pacif. Expl. Exp. 1, p. 232, t. 19): foliis crasse coriaceis obovatis supra glabris subtus ramisque novellis lanato-tomentosis; umbella terminali subsessili confertiflora; calyce quinquesepalo majusculo pedicellisque tomentosissimis, sepalis orbiculatis obtusis petalis duplo brevioribus; staminibus tubo petalorum subæquilongis; antheris oblongis; ovario tomentoso stylo æquilongo; stigmate simplici truncato; capsula tuberculato-rugosa; seminibus rugulosis.

Var. β. foliis subtus aurato-tomentosis; calycis lobis angustioribus. — *P. terminalioides*, var. β. Gray, l. c. p. 231. (M. & B. 337.)

18. PITTOSPORUM CAULIFLORUM (sp. nov.): foliis amplis crasse coriaceis obovatis vel elongato-obovatis obtusissimis basi attenuatis supra glaberrimis subtus petiolisque novellis tomentulosis; pedunculis secus caulem infra folia brevissimis paucifloris cum calyce tomentulosis; sepalis late ovatis petalis quintuplo brevioribus; antheris sagittatis; stylo ovario tomentoso triplo breviore; stigmate bilobo; seminibus leviter rugulosis. — Kaala Mountains, Oahu. — A tree, 30 feet or more high, with a trunk 8 or 10 inches in diameter. Leaves from 3 to 8 inches long, by 15 to 30 lines wide. Petiole half an inch to an inch and more in length. Flowers cream-colored or white, 6 lines long, borne far below the leaves on the naked stems. Capsule an inch in diameter, clothed at first with a fine deciduous tomentum. Endocarp orange-yellow. (M. & B. 601.)

19. PITTOSPORUM TERMINALIOIDES (Planchon, in Herb. Hook.): foliis coriaceis oblongo-obovatis obtusis basi attenuatis subtus (præsertim junioribus) cum inflorescentia brevissima pauciflora tomentosis, pube sæpius ferruginea; pedunculis sæpissime axillaribus; sepalis crassis ovalibus petalis quintuplo brevioribus; staminibus petalis plus dimidio brevioribus; antheris sagittatis; ovario tomentoso stylo æquilongo; stigmate simplici; capsula tomentulosa fere lævi; seminibus scabro-rugosis. — Gray, l. c. p. 231 (*a*). *P. glabrum*, Putterl. Syn. Pittosp. p. 11, pro parte, non Hook. & Arn. (M. & B. 313.)

20. PITTOSPORUM SPATHULATUM (sp. nov.): foliis tenuiter coriaceis spathulatis vel cuneato-oblongis apice rotundato nunc apiculatis ramisque glaberrimis; pedunculis tomentulosis brevibus axillaribus vel infra folia 3–7-floris; sepalis late ovatis obtusis; staminibus petalis plus dimidio brevioribus; antheris sagittatis; ovario tomentoso stylo æquilongo; stigmate capitato; capsula glabra fere lævi; seminibus lævibus. — Kaala Mountains, Oahu. — *P. terminalioides*, var.? γ, Gray, l. c. — A small tree, 15 or 20 feet high. Leaves 3 or 4 inches long, by 1 to $1\frac{1}{2}$ wide. Petiole very short. Flowers white or cream-colored, 5 lines long. Capsule nearly smooth. (M. & B. 602; Remy, 572.)

21. PITTOSPORUM GLABRUM (Hook. & Arn. Bot. Beech. Voy. p. 100, vix Putterl. Pittosp.): undique glabrum; foliis tenuiter coriaceis cuneato-oblongis oblanceolatisve subacuminatis, venulis minus reticulatis; pedunculis brevibus terminalibus seu axillaribus subracemoso-5–9-floris; sepalis ovatis acutis petalis quadruplo brevioribus; staminibus tubum petalorum subæquantibus; antheris oblongis; stylo ovario glabro bis longiore; stigmate truncato; capsula globosa tuberculato-rugosa. — Gray, l. c. p. 229. (M. & B. 203.)

22. PITTOSPORUM ACUMINATUM (sp. nov.): foliis chartaceis oblanceolatis acuminatis glaberrimis; pedunculis axillaribus gracillimis petiolum bis superantibus corymboso-5–8-floris; sepalis bracteisque angustissimis subulatis; staminibus petalis plus dimidio brevioribus; antheris sagittatis; stylo gracili ovario tomentoso longiore; stigmate capitato; capsula globosa tomentosa tuberculato-rugosa. — On the mountains above Waimea, Kauai, 3,000 feet. — A small tree, 15 or 20 feet high; branches slender. Leaves 3 to 6 inches long, 6 to 20 lines wide. Petioles about half an inch long. Peduncles 10 to 20 lines long. Bracts and sepals a line and a half long. Flowers about 5 lines long. Capsule much tuberculate-roughened. (M. & B. 603.)

Caryophyllaceæ.

23. SILENE STRUTHIOLOIDES, Gray, Bot. S. Pacif. Expl. Exp. 1, p. 109, t. 10. (M. & B. 312.)

24. SILENE LANCEOLATA, Gray, l. c. p. 111, t. 10.

SCHIEDEA, *Cham. et Schlecht.*, *Char. Gen. emend.**

Calyx quinquepartitus, persistens. Corolla nulla. Staminodia subpetaloidea 5, hyalina, sepalis opposita. Stamina fertilia 10, imo calyci inserta, quinque sepalis opposita cum basi staminodiorum accreta, quinque alterna breviora. Styli filiformi 3, rarius 4–5–7. Ovarium uni-

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* SYNOPSIS. — Reprinted from the Proceed. Bost. Soc. Nat. Hist., Vol. X., 1866.

§ EUSCHIEDEA. Filamenta capillaria. Styli 3, rarius 4–5, intus stigmatosi. — Flores parvi, thyrsoideo-congesti vel effuse paniculati.

* Panicula deliquescens, effusa: sepala acuminata: folia uninervia.

+ Staminodia apice bifida: filamenta longe exserta.

1. S. NUTTALLII, *Hook.*
2. S. DIFFUSA, *Gray.*

+ + Staminodia lanceolata, acuminata: filamenta calyce breviora.

3. S. AMPLEXICAULIS, *sp. nov.*
4. S. STELLARIOIDES, *sp. nov.*

* * Panicula contracta, ramosa, deliquescens: folia trinervia.

5. S. MENZIESII, *Hook.*
6. S. HOOKERI, *Gray.*

* * * Panicula thyrsoidea, contracta, interrupta: folia uninervia.

+ Staminodia apice bifida: filamenta longe exserta.

7. S. LIGUSTRINA, *Cham. et Schlecht.*
8. S. SPERGULINA, *Gray.*

+ + Staminodia apice bifida: filamenta calyce breviora.

9. S. REMYI, *sp. nov.*

loculare; ovulis plurimis columellæ centrali affixis. Capsula trivalvis, raro 4-5-7-valvis. Semina plurima, estrophiolata. Embryo annularis, albumen farinaceum cingens. — Suffrutices vel herbæ perennes, Sandwicenses, oppositifolii, exstipulati; cymulis thyrsoideo-congestis vel effuse paniculatis, raro cyma pauciflora.

25. SCHIEDEA NUTTALLII, Hook. Ic. Pl. t. 649, 650; Gray, l. c. p. 137. *Eucladus suffruticosus*, Nutt. in herb. Hook. (Remy, 547.)

26. SCHIEDEA DIFFUSA, Gray, l. c. p. 138, t. 11. (Remy, 546.)

27. SCHIEDEA AMPLEXICAULIS (H. Mann, in Proceed. Bost. Soc. Nat. Hist. vol. 10, p. 310, Apr. 1866): suffruticosa; foliis oblongo-linearibus obtusis mucronatis uninerviis basi lata auriculata amplexicaulibus; panicula ramosissima patentissima; pedicellis minutissime hirsutis; sepalis ovato-lanceolatis acuminatis scarioso-fibrilloso-marginatis hispidulis enerviis capsula 3-valvi paullo longioribus; staminodiis lanceolatis apice attenuato integerrimis; filamentis brevibus; seminibus lævibus. — "Kauai or Niihau." — Leaves oblong-linear from a wide auriculate and clasping base, one-nerved, obtuse, mucronate, about 2 inches long, and 5-6 lines wide. Panicle compound, diffusely spreading, bracted, about a foot long, its younger parts and the calyx minutely hirsute. Pedicels capillary, 4-8 lines long. Calyx 2 lines long, sepals ovate-lanceolate, acuminate, with scarious and fibrillose margins. Staminodia lanceolate, with an entire attenuated apex. Stamens shorter than the calyx. Capsule few-seeded, nearly equalling the calyx in length, splitting into 3 valves. Seeds smooth. (Remy, 548[bis].)

28. SCHIEDEA STELLARIOIDES (H. Mann, l. c. p. 310): caule basi suffruticoso ramosissimo; foliis spathulato-linearibus obtusis mucronatis emarginatisve uninerviis, junioribus basi attenuata hirsuto-ciliatis; panicula effusa gracili; pedicellis primum pubescentibus; sepalis attenuato-lanceolatis enerviis capsula 3-valvi paullo longioribus; staminodiis lanceolatis apice attenuato integerrimis; filamentis brevibus; seminibus rugulosis. — On the mountains above Waimea, Kauai. — Bushy and very much branched from a suffruticose base. Finely hirsute in

**** Thyrsus globosus, nunc tripartitus: folia tripli-quintupli-nervia: staminodia integra obtusa: filamenta brevissima.

10. S. GLOBOSA, *sp. nov.*

§ NOTHOSCHIEDEA. Filamenta complanata subulata. Styli 7, undique stigmatosi. Staminodia integra, obtusa, brevissima: filamenta calyce breviora. — Flores pro genere maximi, perpauci, sepalis subpetaloideis.

11. S. VISCOSA *sp. nov.*

the axils of the leaves and on the inflorescence. Leaves numerous, small, spathulate-linear, entire at the obtuse apex and mucronate, or slightly notched, one-nerved, tapering at the hirsute-ciliate base into a very short petiole. Panicle compound, diffusely branched, bracted. Calyx 2 lines long, the sepals lanceolate, acuminate, rather thick, narrowly scarious-margined, longer than the 3-valved capsule. Staminodia, stamens, etc., as in *S. amplexicaulis.* Seeds few, tuberculate-roughened. (M. & B. 595.)

29. Schiedea Menziesii, Hook. Ic. Pl. fol. 649, adnot.

30. Schiedea Hookeri, Gray, l. c. p. 133, adnot.

31. Schiedea ligustrina, Cham. & Schlecht. in Linnæa, 1, p. 46; Fenzl, in Endl. Atakt. Bot. t. 14, & Ann. Wein. Mus. 2, p. 273; Gray, l. c. p. 133. *Portulacea,* Hook. & Arn. Bot. Beech. Voy. p. 188. (M. & B. 578.)

32. Schiedea spergulina, Gray, l. c. t. 11. (M. & B. 342.)

33. Schiedea Remyi (H. Mann, l. c. p. 310): suffruticosa; foliis inferioribus angustato-linearibus uninerviis fasciculatis, superioribus subulatis; panicula thyrsoidea contracta e cymulis brevibus puberulis compositis; sepalis ovatis obtusis plurinerviis capsulam superantibus; staminodiis apice bifidis; filamentis brevibus; seminibus fere lævibus. — Molokai. — Leaves very narrowly linear, 2 – 3 inches long, a line wide, with smaller ones often fascicled in their axils. Inflorescence a very much crowded thyrsus, minutely pubescent. Sepals ovate, obtuse, many-nerved. Staminodia short, bifid at the apex. Stamens short, of about the length of the staminodia. Ovary ovoid. Styles 4 – 5, rather long. Capsule ovoid, shorter than the calyx. Seeds numerous (30 – 40), small. (Remy, 551.)

34. Schiedea globosa (H. Mann, l. c. p. 311): humilis; caulibus e caudice herbaceo erectis simplicissimis; foliis inferioribus obovato-lanceolatis sessilibus 3 – 5-plinerviis, superioribus angustioribus parvis tripli-nerviis; cymulis plurifloribus in capitulum terminale globosum raro trifidum longius pedunculatum arcte congestis; sepalis ovatis obtusis infra medium nervatis capsula ovato-lanceolata 4-valvi brevioribus; staminodiis integerrimis obtusis staminibusque calyce 2 – 3-plo brevioribus; seminibus paucis rugulosis. — Oahu. — Herbaceous, pruinose-puberulent on the upper part of the stem and on the inflorescence, otherwise glabrous. The simple branches rising from the base a span to a foot high, bearing 4 or 5 pairs of leaves. The lower leaves obovate-lanceolate from a narrowed sessile base, somewhat fleshy, about

4 inches long, and an inch wide or less, 3 – 5 nerved, the upper diminished into small subulate bract-like 3-nerved leaves, only three fourths of an inch long, and a line and a half wide. The upright stem bearing a compact globose thyrsus of an inch in diameter (rarely with two lateral ones), composed of numerous many-flowered short cymules. Sepals ovate, obtuse, nerved below the middle, a line and a half long, shorter than the ovate-lanceolate capsule. Staminodia very short, blunt, entire, about the length of the stamens. Seeds few, large for the section, and tuberculate-roughened. (M. & B. 580; Remy, 552.)

35. SCHIEDEA VISCOSA (H. Mann, l. c. p. 311): decumbens, suffruticosa, glanduloso-pubescens; ramis adsurgentibus foliosis apice laxe 2–6-floribus; foliis breviter oblongis utrinque acutissimis petiolatis trinervatis demum glabratis; sepalis ovatis acuminatis plurinerviis capsulam 7-valvem superantibus; filamentis calyce brevioribus staminodia late ovata obtusa 3-plo superantibus, iis staminodiorum oppositis latioribus; seminibus plurimis tuberculato-rugulosis. — At three thousand feet elevation, on the mountains of Waimea, Kauai. — This species differs so entirely in its aspect from the rest of the genus, in its almost trailing manner of growth, and in its peculiarly nerved leaves and large flowers (nearly half an inch long, forming a comparatively simple cyme), as to form quite a distinct section. Plant suffruticose, decumbent and spreading with branches 2 or 3 feet long, sending up suberect flowering stems 8 to 12 inches high. Whole plant covered with a glandular pubescence, which is viscous, especially on the peduncles and pedicels. Leaves $1\frac{1}{2} - 1\frac{3}{4}$ inches long, 4 – 5 lines wide, evenly tapering at each end to a sharp point, below into a margined petiole 2 lines long, becoming glabrate on the upper surface with age, nerved with three well-marked veins running from the base to the apex. The peduncled terminal cymes, composed of 2 – 6 flowers on pedicels about 6 lines long, arising from the axils of small (6 lines long and $1\frac{1}{2}$ line wide) floral leaves. The pubescent calyx 5 – 6 lines long, of five subpetaloid ovate-acuminate many-nerved sepals, which enclose and surpass in length the ovate-lanceolate 7-valved capsule. Staminodia widely ovate, obtuse, small in proportion to the size of the flower, a line long and nearly as wide at the base. Stamens 10; those opposite the sepals inserted with the staminodia, the filaments dilated subulate; those alternate narrowly subulate and a little shorter. Styles 7, short at first and stigmatose all round, but becoming longer with age. Seeds borne on a central placenta, very numerous, tuberculate-roughened with short obtuse points. (M. & B. 579.)

ALSINIDENDRON, *H. Mann.*

Calyx quadripartitus, sepalis decussatim imbricatis ovalibus subcarnosis albidis etiam sub anthesi conniventibus, raro cum quinto minimo interno. Petala et staminodia nulla. Stamina 10, margini disci tenuissimæ basi calycis accreti inserta: filamenta filiformia: antheræ lineari-oblongæ, utrinque emarginatæ. Ovarium uniloculare; ovulis plurimis columellæ centrali affixis: styli 4–7, breviter filiformes, apice intus stigmatosi. Capsula 4–7-valvis, polysperma. Semina estrophiolata.—Frutex Sandwicensis, orgyalis, fere glaber; ramis foliosis; foliis oppositis amplis ovatis ovalibusque cuspidato-acuminatis basi in petiolum subito angustatis eximie trinervatis subeveniis; cymis plurifloribus pedunculatis ex axillis superioribus, floribus subglobosis in pedicellis filiformibus pendulis.

36. A. TRINERVE, H. Mann, l. c. p. 312.—Kaala Mountains, Oahu, at an elevation of about 2,000 feet. Collected probably at the same station by Dr. Hillebrand, in fruit, which proves to be capsular. The generic character is here corrected, or completed in this respect, from a capsule sent from Kew herbarium from Dr. Hillebrand's collection. (M. & B. 582.)

Portulacaceæ.

37. SESUVIUM PORTULACASTRUM, Linn.; Gray, l. c. p. 142. (M. & B. 107.)

38. PORTULACA VILLOSA, Cham. in Linnæa, 6, p. 565; Walp. Repert. 2, p. 234; Gray, Bot. S. Pacif. Expl. Exp. 1, p. 140.

39. PORTULACA SCLEROCARPA, Gray, l. c. p. 141. (M. & B. 340.)

Guttiferæ.

40.* CALOPHYLLUM INOPHYLLUM, Linn.; Gray, Bot. S. Pacif. Expl. Exp. 1, p. 218. (M. & B. 121; Remy, 564.)

Ternstrœmiaceæ.

41. EURYA SANDWICENSIS, Gray, Bot. S. Pacif. Expl. Exp. 1, p. 209. (M. & B. 524; Remy, 562.)

Malvaceæ.

42. GOSSYPIUM TOMENTOSUM, Nutt. mss.; Seem. Fl. Vitiensis, p. 22 (1865). *G. religiosum*, Gray, Bot. S. Pacif. Expl. Exp. 1, p. 179, non Cavanilles. *G. Sandvicense*, Parl. Sp. Coton. p. 37. t. 6. f. B. (1866). (M. & B. 228; Remy, 567.)

43.† GOSSYPIUM RELIGIOSUM, Linn. Syst. Nat. ex Seem. Fl. Vitiensis, p. 22. adnot. *G. Barbadense*, Hook. & Arn. Bot. Beech. Voy. p. 60; Gray, l. c. *G. Taitense*, Parl. Sp. Coton. p. 39, t. 6. f. A.

44. GOSSYPIUM DRYNARIOIDES, Seem. Fl. Vitiensis, p. 22, adnot. A very well marked species. (Remy, 568?)

45. HIBISCUS TILIACEUS, Linn.; Cav. Diss. 3, t. 55; Gærtn. Fruct. t. 135; DC. Prodr. 1, p. 454. *Paritium tiliaceum*, Adr. Juss. in St. Hil. Fl. Bras. Mer. 1, p. 256; Wight, Ic. Pl. Ind. Or. t. 7; Gray, l. c. p. 178. (M. & B. 86.)

46. HIBISCUS YOUNGIANUS, Gaud. Bot. Voy. Freyc. p. 91 (abs. char.); Hook. & Arn. Bot. Beech. Voy. p. 79; Gray, l. c. p. 174. (M. & B. 598; Remy, 559, 561.)

47. HIBISCUS BRACKENRIDGEI, Gray, l. c. p. 175. (Remy, 560.)

48. HIBISCUS ARNOTTIANUS, Gray, l. c. p. 176. *H. Boryanus*, Hook. & Arn. Bot. Beech. Voy. p. 79, non DC. (M. & B. 530.)

49. ABUTILON INCANUM, Don; Gray, l. c. p. 168. *Sida incana*, Link, Enum. Hort. Berol. 2, p. 204; DC. Prodr. 1, p. 468.

50. ABUTILON MENZIESII, Seem. Fl. Vitiensis, p. 15, adnot.

51. SIDA FALLAX, Walp. Reliq. Meyen. p. 306; Gray, l. c. p. 161. *Sida rotundifolia*, Hook. & Arn. Bot. Beech. Voy. p. 79, non Cav. *Sida Diellii*, Gray, l. c. p. 162. *Anoda ovata*, Meyen, Riese, 2, p. 139. (M. & B. 390, 247, 65; Remy, 554.)

52. SIDA SERTUM, Nutt. in Herb. Hook.; Gray, l. c. p. 163. *Sida rotundifolia*, var., Hook. & Arn. Bot. Beech. Voy. p. 79.

53. SIDA MEYENIANA, Walp. Rel. Meyen. p. 307; Gray, l. c. p. 164. *Sida ulmifolia*, Hook. & Arn. Bot. Beech, Voy. p. 79, non Cav. (M. & B. 31, 238; Remy, 555, 558.)

54.† SIDA RHOMBIFOLIA, Linn.; Gray, l. c. p. 158. (M. & B. 66; Remy, 556.)

55.† MALVASTRUM TRICUSPIDATUM, Gray, Pl. Wright. (in Smithson. Contrib. 3) 1, p. 16; Gray, l. c. p. 148. (M. & B. 18.)

Sterculiaceæ.

56.* WALTHERIA AMERICANA, Linn.; Gray, Bot. S. Pacif. Expl. Exp. 1, p. 189. *W. Indica*, Linn. (M. & B. 5; Remy, 569.)

57. WALTHERIA PYROLÆFOLIA, Gray, l. c. p. 190.

57ª.† GUAZUMA TOMENTOSA, H B K., was found by Mr. Brigham.

Tiliaceæ.

58. Elæocarpus bifidus, Hook. & Arn. Bot. Beech. Voy. p. 110, t. 24; Gray, Bot. S. Pacif. Expl. Exp. 1, p. 205. *Beythea bifida*, Endl.; Walp. Repert. 1, p. 365, & 5, p. 121. (M. & B. 125; Remy, 561.)

Zygophyllaceæ.

59. Tribulus cistoides, Linn.; Gray, Bot. S. Pacif. Expl. Exp. 1, p. 125. (M. & B. 33; Remy, 627.)

Geraniaceæ.

60. Geranium multiflorum, Gray, Bot. S. Pacif. Expl. Exp. 1, p. 311, t. 29.

61. Geranium cuneatum, Hook. Ic. Pl. t. 198; Gray, l. c. p. 312, t. 29. Var. α. Menziesii, Hook. l. c.; Gray, l. c. (M. & B. 307; Remy, 628.) Var. β. hypoleucum, Gray, l. c. (M. & B. 433.) Var. γ. hololeucum, Gray, l. c. (M. & B. 429.)

62. Geranium ovatifolium, Gray, l. c. p. 314, t. 30.

63. Geranium arboreum, Gray, l. c. p. 315, t. 31.

64.† Oxalis corniculata, Linn.; Gray, l. c. p. 320.

65.† Oxalis Martiana, Zucc. Oxal. Nachtr. p. 27. (M. & B. 37.)

Rutaceæ.

66. Pelea clusiæfolia, Gray, Bot. S. Pacif. Expl. Exp. 1, p. 340, t. 35; H. Mann, in Proceed. Bost. Soc. Nat. Hist. 10, p. 312. *Clusia sessilis*, Hook. & Arn. Bot. Beech. Voy. p. 80, non Forst. (M. & B. 599.)

67. Pelea sapotæfolia (H. Mann, l. c. p. 312): foliis (amplis chartaceis) quaternatim verticillatis elongato-oblongis emarginatis basi subattenuatis supra glaberrimis subtus præsertim ad costam pubescentibus crebre penninerviis chartaceis longiuscule petiolatis; calycis lobis late ovatis petalis ovatis brevioribus; stylo *quadripartito* ovario longiore; capsula. . . . — Kauai, in the valleys of Kealia and Hanalei, on the windward side of the island. (M. & B. 559.)

68. Pelea auriculæfolia, Gray, l. c. p. 343, t. 36; H. Mann, l. c. p. 313.

69. Pelea Kavaiensis (H. Mann, l. c. p. 313): foliis ovalibus supra glaberrimis subtus præsertim ad costam velutino-villosis petiolatis; floribus in axillis solitariis pedicellatis parvis; calycis lobis ovato-rotundatis petalis ovatis dimidio brevioribus; stylo ovario glabro æquilongo;

capsula parva quadripartita glaberrima. — Kauai, on the mountains above Waimea, at the elevation of three thousand feet. — A small tree, fifteen or twenty feet high. (M. & B.)

70. PELEA ANISATA (H. Mann, l. c. p. 314): glabra; foliis chartaceis oblongis obtusis petiolatis; floribus in axillis solitariis raro binis vel ternis brevissime pedicellatis; calycis lobis late ovatis obtusis petalis ovato-oblongis triplo brevioribus; stylo ovarium bis superante; capsula leviter quadriloba. — Kauai, on various parts of the island, but most abundant in the neighborhood of Hanalei. (M. & B. 557.)

71. PELEA OBLONGIFOLIA, Gray, l. c. p. 343; H. Mann, l. c. p. 315. (M. & B. 208, 235, 376, 600.)

72. PELEA ROTUNDIFOLIA, Gray, l. c. p. 344, t. 37; H. Mann, l. c. p. 315. (M. &. B. 209.)

73. PELEA SANDWICENSIS, Gray, l. c. p. 345, t. 37; H. Mann, l. c. p. 315. *Brunellia Sandwicensis*, Gaud. Bot. Freyc. Voy. p. 93, sine descr.; Hook. & Arn. Bot. Beech. Voy. p. 80. (Remy, 622.)

74. PELEA VOLCANICA, Gray, l. c. t. 38; H. Mann, l. c. (M. & B.)

75. MELICOPE CINEREA, Gray, l. c. p. 350, t. 39; H. Mann, l. c. p. 316. (M. & B. 558.)

76. MELICOPE BARBIGERA, Gray, l. c. p. 351, t. 39; H. Mann, l. c. p. 316. (M. & B. 560.)

77. MELICOPE SPATHULATA, Gray, l. c. p. 352; H. Mann, l. c.

78. MELICOPE ELLIPTICA, Gray, l. c. p. 353; H. Mann, l. c. p. 317. (M. & B. 377.)

PLATYDESMA, *H. Mann.*

Flores hermaphroditi. Calyx quadrisepalus, persistens, imbricatus; sepalis rotundatis, exterioribus majoribus interiora æstivatione includentibus. Petala 4, æstivatione late convoluto-imbricata vel convoluta, ampla, obovata, apice recurva. Discus planus, leviter 4-lobus. Stamina 8, disco inserta, infra medium monadelpha; filamentis nudis ovatis seu ovato-lanceolatis crassis; antheræ sagittatæ, facei interiori infra apicem filamenti adnatæ. Ovarium 4-partitum: stylus centralis: stigmate 4-lobo: ovula in loculis 5, amphitropa. Cocci erecti, omnino discreti, subsucculenti, abortu sæpissime dispermi, endocarpio tenui cartilagineo. Embryo . . . . — Arbuscula Sandwicensis, fere glabra, graveolens. Folia opposita, ampla, simplicia, lanceolata vel obovato-lanceolata, obtusa vel acuminata, petiolata. Cymæ axillares paucifloræ, pedicellis 2-bracteolatis. Flores magni, albi.

79. Platydesma campanulata, H. Mann, l. c. p. 317. — Oahu, on the mountains behind Honolulu, at middle heights. — A small tree. Leaves 5 to 15 inches long. Flowers an inch long. (M. & B. 94.)

80. Zanthoxylum Kaviense (Gray, l. c. p. 354; H. Mann, l. c. p. 318): "inerme, glabrum; foliis alternis pinnatis 3–5-foliolatis; foliolis coriaceis ovalibus integerrimis haud punctatis; paniculis axillaribus compositis; fructibus stipitatis"; — floribus tetrameris; calycis lobis ovato-subulatis petalis fl. masc. lanceolatis triplo, fl. fœm. lineari-ligulatis quadruplo brevioribus; antheris ovalibus; ovario solitario. — Kauai. Hawaii. — The fruit has been described from the specimens of the South Pacific Exploring Expedition. I have described the flowers from a specimen, probably of the same species, collected on Hawaii by Remy, but differing in the thinner texture of the leaves, which appear with the flowers. Calyx four-lobed; the lobes ovate-subulate, about three fourths of a line long, in the male flowers thrice shorter than the lanceolate petals: stamens four, a line in length; filaments capillary; anthers oval. In the female flower the sepals are four times shorter than the linear-ligulate petals, which are imbricated in æstivation; stamens reduced to four glands; ovary unilocular, stipitate; stigma globular. (Remy, 614.)

81. Zanthoxylum Maviense (H. Mann, l. c. p. 319): inerme, pube tenuiter velutina cinereum; foliis alternis 3-foliolatis; foliolis coriaceis ovalibus (lateralibus basi hinc excisa valde inæquilateris) integerrimis haud punctatis; paniculis axillaribus; coccis solitariis estipitatis lunulato-ovoideis. — Maui. — The specimen is apparently from an unarmed tree, bearing mature fruit only; it is cinereous with a fine velutinous pubescence, especially on the under surface of the alternate trifoliolate leaves. Petioles fifteen to twenty lines long. Leaflets ovate, truncated at the base; the two lateral ones unequal, the upper base being three lines shorter than the lower, two to two and a half inches long by fifteen to twenty lines wide. Panicle several-flowered. Carpel solitary, estipitate, four to five lines long, lunulate-ovoid, becoming two-valved; the endocarp adnate. Seed solitary, filling the cell. Known only from Remy's collection. (Remy, 615.)

82. Zanthoxylum (Blackburnia) dipetalum (H. Mann, l. c. p. 319): inerme, glabrum; foliis alternis 3–9-foliolatis; foliolis coriaceis oblongis vel ovatis integerrimis punctatis; paniculis florum sterilium compositis; petalis 2 ovalibus crassissimis æstivatione valvatis calyce 4-dentato quadruplo longioribus; antheris oblongis: — flores fertiles

fructusque ignoti.—Oahu?—A tree about thirty feet high, entirely glabrous. The specimens furnish immature sterile flowers. Leaves alternate, 3-9-foliolate, petioled. Leaflets two to four inches long by seven to twenty lines wide, oblong or oblong-ovate, obtuse, coriaceous, punctate, pinnately veined, entire, equal at the base, and with one or two small (three to nine lines long) foliar bodies arising from just below the lower leaflets, which, were it not for their anomalous position, might be likened to large stipules. Panicles axillary or terminal, cymosely many-flowered, with a very thick and nodose peduncle and axis. Calyx small, less than a line long, four-lobed. Petals only two, oval, valvate in æstivation and remarkably thick, in the bud three or four lines long, probably caducous. Stamens four; filaments short, subulate; anthers oblong. (Collected only by Hillebrand.)

Ilicineæ.

83. BYRONIA SANDWICENSIS, Endl. in Ann. Wein. Mus. 1, p. 184, & Gen. Pl. p. 1093; Gray, Bot. S. Pacif. Expl. Exp. 1, p. 296, t. 26. *Ilex? anomala*, Hook. & Arn. Bot. Beech. Voy. p. 111, t. 25. (M. & B. 205; Remy, 578.)

Celastraceæ.

84. PERROTTETIA SANDWICENSIS, Gray, Bot. S. Pacif. Expl. Exp. 1, p. 291, t. 24. (M. & B. 93; Remy, 575, 576.)

Rhamnaceæ.

85. COLUBRINA ASIATICA, Brongn. Rham. in Ann. Sci. Nat. 10, p. 368; Guillem. Zeph. Tait. p. 68. *Ceanothus Asiaticus*, Linn.; Cav. Ic. 5, t. 440; DC. Prodr. 2, p. 30. *C. capsularis*, Forst. Prodr. Fl. Ins. Aust. p. 18. (Remy, 580; W. T. Brigham.)

86. COLUBRINA OPPOSITIFOLIA (Brongn. in Herb. Gray): glabra, inermis; foliis oppositis oblongo-ovatis v. ovalibus integerrimis coriaceis penninerviis; cymis petiolo subæquilongis.—At once distinguished by its opposite entire leaves. (Remy, 581; Hillebrand, 128.)

87. ALPHITONIA EXCELSA, Riessek, in Endl. Gen.; Benth. Fl. Aust. 1, p. 414. *A. zizyphoides*, Gray, Bot. S. Pacif. Expl. Exp. 1, p. 278, t. 22. *A. franguloides*, Gray, l. c. p. 280, t. 22. *Colubrina excelsa*, Fenzl in Hügel, Enum. 20. *Zizyphus pomaderroides*, Fenzl, l. c. *Rhamnus zizyphoides*, Sol. in Forst. Prodr. Ins. Aust. p. 90, no. 510 (absq. char.); Spreng. Syst. 1, p. 768; DC. Prodr. 2, p. 27. *Ceanothus dealbatus*, Dryand. mss. in Herb. Mus. Brit. *Zizyphoides argentea*,

Sol. Prim. Fl. Pacif. p. 378. *Pomaderris zizyphoides*, Hook. & Arn. Bot. Beech. Voy. p. 61. *Rhamnus incana*, Roxb.; Spreng. Syst. Veg. Cur. Post. p. 86? fide spec. Hort. Calc. (Remy, 582, 583, 584.)

88. GOUANIA VITIFOLIA, Gray, l. c. p. 283.

89. GOUANIA ORBICULARIS (Walp. Rel. Meyen. p. 323): ramis erectis v. decumbentibus cum inflorescentia sericeo-pubescentibus vel glabratis; foliis orbiculatis seu oblongis integerrimis coriaceis penninerviis; cymulis axillaribus confertis petiolum haud superantibus; fructibus crasse alatis. — Gray, l. c. p. 284. *G. integrifolia*, Meyen, Riese, 2, p. 156. non Lam. (M. & B. 344.) Var. β. pedunculis gracillimis folio longe petiolato paullo brevioribus. (Remy, 586.)

Sapindaceæ.

90. DODONÆA VISCOSA, Linn. Mant. p. 238; Gray, Bot. S. Pacif. Expl. Exp. 1, p. 260; Seem. Fl. Vitiensis, p. 49. *D. spathulata*, Smith, in Rees, Cycl. no. 2; Gray, l. c. p. 261. (M. & B. 308, 239, 410 pro parte.)

91. DODONÆA ERIOCARPA, Smith, in Rees, Cycl.; Gray, l. c. p. 261. (M. & B. 410 pro parte; Remy, 570.)

92.* CARDIOSPERMUM HALICACABUM, Linn., var. *C. microcarpum*, H B K. (M. & B. 380.)

Anacardiaceæ.

93. RHUS SEMIALATUM, Murr. in Comm. Gœtt. 1784, & in Linn. Syst. Veg. ed. 14. *R. Sandwicensis*, Gray, in Bot. S. Pacif. Expl. Exp. 1, p. 369. (M. & B. 412.)

Connaraceæ.

94. CONNARUS? KAVAIENSIS (sp. nov.): arborea, glaber; foliis nunc palmato- nunc pinnato-3–5-foliolatis; foliolis crasse coriaceis ovalibus seu obovatis venis subtus prominulis transverse costatis, terminali sæpe basi inæquali, lateralibus plerumque parvis difformibus margine revolutis (an monstruosis?); pedunculo paucifloro oppositifolio; sepalis 4 minutis incrassatis; folliculo obovato lignescente glabro substipitato; semine atro-nitido exarillato loculum implente, testa crassa crustacea; radicula supera. — Mountains above Waimea, Kauai, 3000 feet. — A tree, 25 or 30 feet high, and glabrous throughout. Leaves palmately or pinnately 3–5-foliolate: leaflets 3–5 inches long, 2–3 wide, the upper surface punctuated with black dots. The reticulations are much imbedded, and therefore not very conspicuous; the two lower and

lateral leaflets are very small, about an inch long, and with the margins strongly revolute (perhaps a diseased state?). Peduncles opposite the leaves, three to four inches long, and few- (to 8?) flowered. As the specimens are only in fruit the flowers are unknown, but the four very small and thick persistent sepals appear to have been slightly imbricated, and about a line long. Follicle quite woody, an inch long, and entirely filled by the very hard black seed, which seems to be inserted along the whole ventral suture, and is entirely without an arillus! Cotyledons thick and fleshy, plano-convex. Radicle short, included, superior. — Only a single tree seen. (M. & B. 581.)

Leguminosæ.

95.† CROTALARIA ASSAMICA, Benth., in Hook. Lond. Journ. Bot. 2, p. 481. (M. & B. 62.)

96.* CROTALARIA SERICEA, Retz.; W. & Arn. Prodr. 1, p. 186.

97.† CROTALARIA LONGIROSTRATA, Hook. & Arn. Bot. Beech. Voy. p. 285. (W. T. Brigham.)

98.† INDIGOFERA ANIL, Linn. (M. & B. 4.)

99.* TEPHROSIA PISCATORIA, Pers.; Guill. Zeph. Tait. p. 62; Gray, Bot. S. Pacif. Expl. Exp. 1, p. 407. (M. & B. 61.)

100. SESBANIA TOMENTOSA, Hook. & Arn. Bot. Beech. Voy. p. 286, excl. loco natali. *Agati tomentosa*, Nutt. in Herb. Hook.; Gray, l. c. p. 409. (Remy, 654, 655; W. T. Brigham.)

101.* SESBANIA GRANDIFLORA, Poir. Dict. 7, p. 127. *Agati grandiflora*, Desv. Jour. Bot. *A. coccinea*, Desv. l. c. (M. & B. 589.)

102. DESMODIUM SANDWICENSE, E. Meyer, Ind. Sem. Hort. Regiomont. 1850, & in Linnæa, 24, p. 230; Gray, l. c. p. 433. — This has very much the aspect of an introduced plant, as it is generally supposed to be, by the residents. (M. & B. 26; Remy, 657.)

103.* DESMODIUM TRIFLORUM, DC. Prodr. 2, p. 334; Gray, l. c. p. 432. (M. & B. 115; Remy, 658.)

104. VICIA MENZIESII, Spreng. Syst. Veg. 3, p. 267; Gray, l. c. p. 420. *V. grandiflora*, Smith, in Rees, Cycl. no. 7. (Remy, 656.)

105. ERYTHRINA MONOSPERMA, Gaud. Bot. Freyc. Voy. p. 486, t. 114; Hook. & Arn. l. c. p. 81; Gray, l. c. p. 444. (M. & B. 394.)

106. STRONGYLODON LUCIDUM, Seem. Fl. Vitiensis, p. 61. *Glycine lucida*, Forst. Prodr. n. 272. *Rhynchosia lucida*, DC. Prodr. 2, p. 387. *Strongylodon ruber*, Vogel, in Linnæa, 10, p. 585; Gray, l. c. p. 446, t. 48. *Mucuna altissima*, Hook. & Arn. Bot. Beech. Voy. p. 81, non alior. (M. & B. 134; Remy, 672.)

107. Mucuna gigantea, DC. Prodr. 2, p. 405; Guill. Zeph. Tait. p. 62; Gray, l. c. p. 442; Seem. Fl. Vitiensis, p. 59. (Remy, 670.)

108. Mucuna urens, DC. Prodr. 2, p. 405; Gray, l. c. p. 443. *Dolichos urens*, Linn. (M. & B. 395.)

109. Dioclea violacea, Mart.; Benth. in Ann. Wien. Mus. 2, p. 133; Gray, l. c. p. 439; Seem. Fl. Vitiensis, p. 57. (Remy, 673.)

110. Canavalia galeata, Gaud. Bot. Freyc. Voy. p. 486, adn.; Gray, l. c. p. 441; Vogel, in Linnæa, 10, p. 584. *Dolichos galeatus*, Gaud. l. c. p. 486, t. 115. *Canavalia Gaudichaudii*, Endl. Syn. Fl. Ins. Aust. in Ann. Wein. Mus. 1, p. 186. Var. β. pubescens, Gray, l. c. p. 441. *C. pubescens*, Hook. & Arn. Bot. Beech. Voy. p. 81; Vogel, in Linnæa, 10, p. 584. (M. & B. 393; Remy, 664.)

111.* Phaseolus Truxillensis, H B K. Nov. Gen. Am. 6, p. 451. *P. Cummingii*, Benth. Comm. Legum. (in Ann. Wein. Mus.) p. 75. *P. amœnus*, Sol. in Forst. Prodr. Ins. Aust. no. 553, abs. char. *P. rostratus*, Wall. Pl. Asiat. Rar. 1, p. 50, t. 63. (Remy, 674, foliis angustis.)

112.* Phaseolus semierectus, Linn.; Jacq. Ic. Rar. t. 558. (M. & B. 47.)

113. Vigna lutea, Gray, l. c. p. 452; Seem. Fl. Vitiensis, p. 62. *Scytalis anomala*, Vogel, Rel. Meyen. p. 33? (W. T. Brigham.)

114. Vigna Oahuensis, Vogel, in Linnæa, 10, p. 585; Gray, l. c. p. 450. *V. villosa*, Hook. & Arn. Bot. Beech. Voy. p. 81, non Savi.

115. Vigna Sandwicensis, Gray, l. c. p. 451, t. 50. (M. & B. 445; Remy, 675.)

116.* Dolichos Lablab, Linn. Spec. p. 725. (M. & B. 48.)

117.* Cajanus Indicus, Spreng. Syst. 3, p. 248; Gray l. c. p. 453. (M. & B. 52.)

118. Sophora (Edwardsia) chrysophylla, Seem. Fl. Vitiensis, p. 66. *Edwardsia chrysophylla*, Salisb.; Gray, l. c. p. 459. (M. & B. 352; Remy, 677.)

119. Cæsalpinia (Guilandina) Bonduc, Benth.; Seem. l. c. *Guilandina Bonduc*, Linn.; Gray, l. c. p. 461. (M. & B. 109.)

120. Cæsalpinia Kavaiensis (sp. nov.): arborea, inermis; ramis novellis pubescentibus; foliis abrupte-bipinnatis; pinnulis 3–5-jugis; foliolis oblongis obtusis emarginatisve basi obtusis vel in petiolum brevem attenuatis; racemis plurifloris; pedicellis floribus duplo longioribus; staminibus corollam paullo superantibus; filamentis hirsutis. — On the leeward verge of the mountains of Kauai. — A small tree with

remarkably durable, very dark-colored wood, the "Uhiuhi" of the natives. Leaves with about 3 pairs of primary pinnæ. Leaflets one or two inches long, $\frac{1}{2}$ to $\frac{3}{4}$ inch wide, paler underneath, glabrous excepting the base of the midrib below in the young parts. Flowers purple, $\frac{3}{4}$ of an inch long. (M. & B.)

121. Cassia Gaudichaudii, Hook. & Arn. Bot. Beech. Voy. p. 81; Gray, l. c. p. 463. (M. & B. 13; R. 680, 681.)

122. Acacia Koa, Gray, l. c. p. 480. *Acacia heterophylla*, Hook. & Arn. Bot. Beech. Voy. p. 81. (M. & B. 78; Remy, 689.)

123.† Acacia Farnesiana, Willd. Spec. 4, p. 1083. (M. & B.)

Rosaceæ.

124. Rubus Hawaiensis, Gray, Bot. S. Pacif. Expl. Exp. 1, p. 504, t. 56. (M. & B.)

125. Rubus Macræi, Gray, l. c. p. 505, t. 57. (M. & B. 425.)

126. Fragaria Chilensis, Ehrh.; Gray, l. c. (M. & B. 424.)

127. Acæna exigua, Gray, l. c. p. 498. (M. & B. 431.)

128. Osteomeles anthyllidifolia, Lindl. in Trans. Linn. Soc. 13, p. 98, t. 8; Gray, l. c. p. 507. (M. & B. 423.)

Saxifragaceæ.

129. Broussaisia arguta, Gaud. Bot. Freyc. Voy. p. 479, t. 69; Gray, Bot. S. Pacif. Expl. Exp. 1, p. 683, t. 87; Hook. & Arn. Bot. Beech. Voy. p. 84. *B. pellucida*, Gaud. Bot. Bonite, t. 9, sine descr.; Gray, l. c. p. 685. The character of the more or less superior ovary is inconstant: that of the whorled leaves (in threes) in *B. pellucida* appears insufficient to warrant its separation as a distinct species, though, as far as known, it is constant. (M. & B. 320, 421, 529; Remy, 515.)

Droseraceæ.

130. Drosera longifolia, Linn. pro parte; Fries Novit. p. 82; Gray, Bot. S. Pacif. Expl. Exp. 1, p. 100. *D. Anglica*, Huds. Fl. Angl. p. 135; DC. Prodr. 1, p. 318; Hook. Brit. Fl., & Fl. Bor.-Am. 1, p. 81.

Halorageæ.

131. Gunnera petaloidea, Gaud. Bot. Freyc. Voy. p. 512; Gray, Bot. S. Pacif. Expl. Exp. 1, p. 629, t. 78, 79. (M. & B. 626; Remy, 165.)

Myrtaceæ.

132. Metrosideros polymorpha, Gaud. Bot. Voy. Freyc. p. 99, & 482, t. 108, 109; Hook. & Arn. Bot. Beech. Voy. p. 82; Gray, Bot. S. Pacif. Expl. Exp. 1, p. 562. (M. & B. 72, var. β; 96, var. γ; 96[a], var. ζ.) Var. lutea: floribus flavis. *M. lutea*, Gray, l. c. p. 560, t. 69, B. (M. & B. 212.)

133. Metrosideros rugosa, Gray, l. c. p. 561, t. 69, A.

134. Metrosideros macropus, Hook. & Arn. Bot. Beech. Voy. p. 83; Gray, l. c. p. 564, t. 70. (M. & B.)

135.† Psidium Guajava, Linn. Spec. ed. 1, p. 470; Gray, l. c. p. 550. (M. & B.)

136.* Eugenia (Jambosa) Malaccensis, Linn. Spec. p. 672; Gray, l. c. p. 510. Some trees bear only pure white flowers, though the more common color is red-purple. (M. & B. 119.)

137. Eugenia (Syzygium) Sandwicensis, Gray, l. c. p. 519. This is one of the largest forest trees, growing at times to a diameter of four or five feet at the base. (M. & B. 204.)

Lythraceæ.

138. Lythrum maritimum, H B K.; Gray, Bot. S. Pacif. Expl. Exp. 1, p. 606. (M. & B. 8; Remy, 632, 633.)

139.† Cuphea Balsamona, Cham. & Schlecht. in Linnæa, 2, p. 363. (Remy, 635.)

Onagraceæ.

140.* Jussiæa villosa, Lam.; W. & Arn. Prodr. Fl. Penins. 1, p. 336. *J. octofila*, DC. Prodr. 3, p. 57. *J. octonervia*, Lam.; Walp. in Rel. Meyen. p. 326; Gray, Bot. S. Pacif. Expl. Exp. 1, p. 619. (M. & B. 46.)

Cucurbitaceæ.

141.* Lagenaria vulgaris, Ser. in DC. Prodr. 3, p. 299; Seem. Fl. Vitiensis, p. 106.

142.* Cucurbita maxima, Duch. in Lam. Dict. 2, p. 151; Seem. Fl. Vitiensis, p. 107, adnot.

143. Sicyos (Sicyocarya) pachycarpus, Hook. & Arn. Bot. Beech. Voy. p. 83; Gray, Bot. S. Pacif. Expl. Exp. 1, p. 650, t. 80. (M. & B. 444; Remy, 537.)

144. Sicyos (Sicyocarya) macrophyllus, Gray, l. c. t. 81.

145. Sicyos (Sicyocarya) cucumerinus, Gray, l. c. p. 652, t. 82. (M. & B. 604, var. γ.)

146. SICYOS (SICYOCARYA) MICROCARPUS (sp. nov.): foliis cordato-rotundis obtuse 4–6-angulatis serratis dentibus mucronulatis supra papilloso-scabridis subtus hispidulo-puberulis; pedunculis masculis elongatis paucifloris, fœmineis brevissimis; fructibus perplurimis pusillis ovato-pyramidatis rostrato-apiculatis inermibus puberulis in capitulum globosum arcte congestis. — Oahu. — Stem slender, strongly angled. Leaves on slender petioles of more than their own length, 1 to 2½ inches in diameter, membranaceous. Male panicles on very slender axillary peduncles, exceeding the leaves in length. Female flowers 30 to 40 in a head; the fruit but 2 lines long, and quite sessile on the apex of a peduncle only 2 or 3 lines long. — Known only from Remy's collection. (Remy, 541.)

Papayaceæ.

147.* PAPAYA VULGARIS, DC. in Lam. Dict. vol. 5, p. 2. *Carica Papaya*, Linn.; Gray, Bot. S. Pacif. Expl. Exp. 1, p. 640.

Begoniaceæ.

148. HILLEBRANDIA * SANDWICENSIS, Oliver, in Trans. Linn. Soc. 25, p. 362, t. 46. An interesting new genus, of a single species, first collected by Mr. Baldwin, of Lahaina, W. Maui, in the mountain valleys behind that town, where also Hillebrand obtained his specimens; seen abundantly and collected by us on the mountains of Kauai. (M. & B. 583.)

Umbelliferæ.

149. HYDROCOTYLE INTERRUPTA, Muhl.; Gray, Bot. S. Pacif. Expl. Exp. 1, p. 692. (M. & B. 28.)

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* HILLEBRANDIA, Oliver, l. c. "Flores monoici. Masculi: Sepala 5. Petala 5, parva, cucullata, sepalis alterna. Stamina indefinita, filamentis liberis, antheris oblongis ellipticisve muticis rima marginali dehiscentibus. Fœminei: Calyx tubo hemisphœrico exalato, limbo perigyno 5-partito. Petala 5, eis fl. masc. similia, perigyna, lobis calycis alterna. Styli 5, distincti, persistentes, lobis calycis oppositi, bifurcati, lobis spiraliter stigmatosis. Ovarium apice liberum, hians, subuniloculare; placentis 5 parietalibus bilamellatis utrinque ovuliferis plus minus basi irregulariter coalitis. Capsula membranacea, vertice exserta, foramine lato inter stylos aperta. Semina indefinita, oblongo-obovoidea, exalbuminosa, testa areolata; embryone cotyledonibus brevibus, radicula obtusa. — Herba habitu omnino *Begoniæ:* differt floribus petaliferis, placentatione atque capsula apice hiante indehiscente."

150. SANICULA SANDWICENSIS, Gray, l. c. p. 705.

151.† DAUCUS PUSILLUS, Michx. Fl. Bor.-Am. 1, p. 164; Gray, l. c. p. 711.

Araliaceæ.

152. HEDERA GAUDICHAUDII, Gray, Bot. S. Pacif. Expl. Exp. 1, p. 719, t. 90. *Aralia trigyna*, Gaud. Bot. Freyc. Voy. p. 474, t. 98. *Panax? Gaudichaudii*, DC. Prodr. 4, p. 253; Hook. & Arn. Bot. Beech. Voy. p. 84. Var. *β. Panax? ovatum*, Hook. & Arn. l. c. (M. & B. 379.)

153. HEDERA PLATYPHYLLA, Gray, l. c. p. 720, t. 91. *Panax? platyphyllum*, Hook. & Arn. l. c. (M. &. B. 605.)

154. HEPTAPLEURUM (PTEROTROPIA *) KAVAIENSE (sp. nov.): arboreum; foliis impari-pinnatis, junioribus inflorescentiaque dense furfuraceo-puberulis demum glabratis; foliolis 15 – 19 coriaceis elongato-oblongis acutiusculis integerrimis basi truncatis brevi-petiolatis; panicula composita; floribus racemoso-umbellatis; umbellis 10 – 20 floris; petalis per anthesin patentibus staminibusque 6; stylo longiusculo; ovario subsemisupero 4-loculari. — Mountains above Waimea, Kauai, at an elevation of 2000 – 3000 feet. — A large, soft-wooded tree, often 40 or 50 feet high. Leaves two feet long, leaflets 7 or 8 inches long, 2 inches wide. Flowers nearly half an inch across when expanded. Drupe 5 or 6 lines long, pointed with the sulcate style and stigma. (M. & B. 606.)

155. HEPTAPLEURUM (PTEROTROPIA) DIPYRENUM (sp. nov.): arborescens; foliis impari-pinnatis, junioribus inflorescentiaque dense furfuraceo-puberulis demum glabratis; foliolis 13 – 15 coriaceis oblongis vel ovatis obtusis integerrimis basi cordatis brevissime petiolatis; panicula composita; floribus racemoso-umbellatis; umbellis 6 – 12-floris; stigmatibus 2 sessilibus; ovario maxima parte supero biloculari (an semper?). — Lanai. — A small tree, 15 or 20 feet high. Leaves

* Ovarium semisuperum. Folia impari-pinnata. — (Stylus aut longiusculus, aut nullus.) — Unless genera are founded upon the foliage merely, these two Hawaiian species must apparently be referred to *Heptapleurum*, Gærtn. (*Paratropia*, DC.), in which, however, they form a marked section, on account of their pinnate leaves. The summit of the ovary is more or less free in several of the genuine species; in one of ours the drupe is about one third, in the other even two thirds superior. One of them has a conspicuous style and a 4-lobed stigma; the other two sessile stigmas, just as Miquel's two sections differ; and one of them is remarkable for the extreme reduction in the number of the carpels.

a foot or more long. Leaflets 3 inches long, 15 to 20 lines wide. Inflorescence (in both species) compound racemose-umbellate, both the primary divisions, or peduncles, and the secondary, or pedicels, umbellate at the apex and racemose below. Immature drupe four lines long. Flowers unknown. (M. & B. 349.)

156. Reynoldsia Sandwicensis, Gray, Bot. S. Pacif. Expl. Exp. 1, p. 724, t. 92. (M. & B. 607.)

157. Tetraplasandra Hawaiensis, Gray, l. c. p. 728, t. 94. (M. & B. 378.)

158. Gastonia? Oahuensis, Gray, l. c. p. 726. A small tree, 15 or 20 feet high, known to the natives as "Ohe mauka" (while *Reynoldsia Sandwicensis* is "Ohe makai"); seen by me in the Kaala mountains, but unfortunately without flower or fruit, so that the genus remains as doubtful as ever: probably it is no *Gastonia.* There are fragments of three other Hawaiian Araliaceæ in the collections.

Loranthaceæ.

159. Viscum moniliforme, Blume. Bijdr. p. 667, & Fl. Jav. Loranth. t. 25; Cham. & Schlecht. in Linnæa, 3, p. 202; Gray, Bot. S. Pacif. Expl. Exp. 1, p. 744. (M. & B. 7.)

Rubiaceæ.

160. Coprosma rhynchocarpa, Gray, in Proceed. Amer. Acad. 4, p. 48. (Remy, 333.)

161. Coprosma longifolia, Gray, l. c. p. 48. (M. & B. 132.)

162. Coprosma foliosa, Gray, l. c. p. 48. (M. & B. 531, 609; Remy, 629bis.)

163. Coprosma pubens, Gray, l. c. p. 49. (M. & B. 561.)

164. Coprosma Menziesii, Gray, l. c. p. 49. (M. & B. 317, 454, 455; Remy, 334.)

165. Coprosma ernodeoides, Gray, l. c. p. 49. (M. & B. 453; Remy, 317, 318.)

166. Nertera depressa, Banks, in Gærtn. Fr. 1, p. 124, t. 26. (M. & B. 128.)

167.† Richardsonia scabra, St.-Hil. (Remy, 319.)

168. Pæderia fœtida, Linn.; DC. Prodr. 4, p. 471. (M. & B. 522.)

169. Canthium lucidum, Hook. & Arn. Bot. Beech. Voy. p. 65. *Myonima umbellata*, Hook. & Arn. l. c. p. 86. (M. & B. 346; Remy, 329.)

170. Psychotria hexandra (sp. nov.): glabra; stipulis amplis foliaceis ovatis connatis petiolum vix adæquantibus deciduis; foliis oblanceolatis utrinque acuminatis supra viridibus subtus pallidis, venis primariis 10 – 14; cyma decomposita; floribus hexameris; calyce cupuliformi 6-dentato; corolla fauce villosa, limbo tubo subinfundibuliformi triplo breviore; antheris stylisque subinclusis; stigmate bifido. — On the mountains above Waimea, Kauai. — A large shrub. Leaves 3 to 6 inches long, 1 to 1¾ wide, abruptly acuminate at the apex, and tapering to a narrowly cuneate base, paler beneath. Flowers white, a half to three fourths of an inch long. (M. & B. 564, 570.)

171. Psychotria grandiflora (sp. nov.): fere glabra; stipulis caducis; foliis obovatis vel oblongo-ovatis obtusis margine tenuiter revolutis basi in petiolum brevem angustatis coriaceis, venis primariis conspicuis utrinque 6 – 9, venulis reticulatis; cyma 12 – 20 flora minute ferrugineo-puberula; limbo corollæ tubo subinfundibuliformi triplo breviore; antheris stylisque breviter exsertis; stigmate emarginato; fructibus ovalibus 8-costatis calycis limbo parvo cupuliformi coronatis; pyrenis cartilagineis intus planis dorso convexo tricostatis. — On the mountains above Waimea, Kauai. — A large shrub or small tree, 20 feet high. Leaves 2 to 4 inches long, 1 to 2 inches wide, obtuse at both ends, or tapering slightly into the short petiole, dark green. Cyme on a long peduncle, nearly equalling the leaves. Corolla waxy white, three fourths of an inch long, very handsome. (M. & B. 566.)

172. Straussia Kaduana, Gray, l. c. p. 43. *Coffea Kaduana*, Cham. & Schlecht. in Linnæa, 4, p. 33; Hook. & Arn. Bot. Beech. Voy. p. 86; Walp. in Rel. Meyen. p. 352. (M. & B. 563, 567; Remy, 321, 325.)

173. Straussia Mariniana, Gray, l. c. p. 43. *Coffea Mariniana*, Cham. & Schlecht. l. c. *Coffea Chamissonis*, Hook. & Arn. l. c. The only characters upon which this species can be kept distinct from the first are, so far as the specimens now show, the *slightly longer* tube of the corolla, which is *bearded within.*

174. Straussia Hawaiensis, Gray, l. c. p. 43.

175. Bobea elatior, Gaud. Bot. Freyc. Voy. p. 473, t. 93; Gray, l. c. p. 36. (M. & B. 114; Remy, 336, 337.)

176. Bobea brevipes, Gray, l. c. p. 36. (M. & B. 621.)

177. Guettardella Sandwicensis, H. Mann. *Chomelia? Sandwicensis*, Gray, l. c. p. 38. (M. & B. 341.)

178.* Morinda citrifolia, Linn. (M. & B. 225.)

179. GARDENIA BRIGHAMII (sp. nov.): arborescens, inermis; foliis ovatis basi rotundatis breviter petiolatis, costa subtus hispidula; stipulis ovatis acutis deciduis, basi persistente hispida cupuliformi; flore terminali sessili; calycis tubo angulato, limbo 4-partito, lobis verticalibus lineari-lanceolatis foliaceis corollæ hypocraterimorphæ tubum adæquantibus; stigmate clavato; bacca papillosa imperfecte 3-6-loculari. — West end of Lanai; also Kaala Mountains, and Nuuanu Valley, Oahu. — Leaves 1 to 4 inches long, 8 to 25 lines wide, obtuse, quite veiny. Sepals at first linear-lanceolate, somewhat wider in fruit, an inch long. Berry slightly ribbed by the decurrent costa of the sepals, rather more than an inch long. Closely allied to *G. Taitensis*, from which it differs in the rounder leaves and longer lobes of the calyx. I take pleasure in dedicating this species to my friend and companion Mr. W. T. Brigham. (M. & B. 348.)

180. GARDENIA REMYI (sp. nov.): arborea, inermis; foliis amplis oblongo-ovatis breviter petiolatis coriaceis; stipulis cupuliformibus truncatis vel breviter utrinque acuminatis tarde deciduis; flore terminali; calycis limbo 4-partito, lobis verticalibus ovatis coriaceis reticulato-venosis tubum corollæ superantibus; corollæ lobis ovatis basi angustatis; bacca papillosa. — Woods on the windward side of Kauai, and on the mountains above Honolulu, Oahu. — A tree, often 40 feet high. Leaves 3 to 8 inches long, $1\frac{1}{2}$ to 3 or 4 inches wide, obtuse at both ends, or shortly acuminate, strongly veined. Lobes of the calyx an inch or more long, nearly twice the length of the corolla-tube. Corolla, as in the preceding species, white and very fragrant, an inch or more in diameter. (M. & B. 565; Remy, 344.)

181. GOULDIA SANDWICENSIS, Gray, l. c. p. 310. *Kadua affinis*, Cham. & Schlecht. in Linnæa, 4, p. 164. Var. TERMINALIS. *Petesia? terminalis*, Hook. & Arn. Bot. Beech. Voy. p. 85. Var. CORIACEA. *Petesia? coriacea*, Hook. & Arn. l. c. Var. HIRTELLA. (M. & B. 131, 382, 416, 418, 526; Remy, 331.)

182. KADUA LAXIFLORA (sp. nov.): fruticosa; ramis pedunculis pedicellisque glaberrimis; foliis chartaceis minute strigosis sessilibus, inferioribus oblongis utrinque acuminatis, superioribus floralibusque cordatis acuminatis; cyma laxe pluriflora; lobis calycis lanceolatis ovario bis longioribus; capsula apice convexiuscula; seminibus immarginatis. — Wailuku Valley, West Maui. — A sarmentose shrubby species. Stem somewhat four-angled. Leaves 4 to 6 inches long, $1\frac{1}{2}$ to 2 inches wide; the floral leaves an inch or more long. Calyx-lobes 2 to 3 lines long, half the length of the corolla. (M. & B. 422.)

183. Kadua centranthoides, Hook. & Arn. Bot. Beech. Voy. p. 85; Gray, l. c. p. 317.

184. Kadua glomerata, Hook. & Arn. l. c.; Gray, l. c. (M. & B.)

185. Kadua cordata, Cham. & Schlecht. in Linnæa, 4, p. 160; Hook. & Arn. l. c.; Gray, l. c. (M. & B. 210; Remy, 352, 353.)

186. Kadua Cookiana, Cham. & Schlecht. in Linnæa, 4, p. 158; Gray, l. c. p. 317.

Var.? elatior: cyma decomposita pluriflora; foliis petiolatis lanceolato-linearibus utrinque acuminatissimis. — Kauai; Molokai. — Probably a luxuriant variety of *K. Cookiana*, with which it agrees in the essential characters, but a much larger plant than Chamisso's, often two feet high, the leaves 6 to 8 inches long, and 6 or 8 lines wide. The cyme is much more ample, but the flowers are hardly larger than those of the original specimens. (M. & B. 569.)

187. Kadua parvula, Gray, l. c. p. 317.

188. Kadua glaucifolia, Gray, l. c. p. 318. (M. & B. 568.)

189. Kadua Menziesiana, Cham. & Schlecht. in Linnæa, 4, p. 160; Gray, l. c. p. 318. *Hedyotis coriacea*, Smith, in Rees, Cycl. 17. *H. conostyla*, Gaud. Bot. Freyc. Voy. p. 147, t. 94. *Kadua Smithii*, Hook. & Arn. l. c. p. 86. (M. & B. 319.)

190. Kadua acuminata, Cham. & Schlecht. in Linnæa, 4, p. 163; Hook. & Arn., l. c. p. 85; Gray, l. c. p. 318. (M. & B. 234.)

191. Kadua petiolata, Gray, l. c. p. 318. (M. & B. 523.)

192. Kadua grandis, Gray, l. c. p. 318. (M. & B. 417; Remy, 350, 351.)

Compositæ.

193. Adenostemma viscosum, Forst. (M. & B. 12; Remy, 263.)

194.† Ageratum conyzoides, Linn. (M. & B.; Remy, 229.)

195. Lagenophora Maviensis (sp. nov.): minutim viscoso-pubescens, scapo valido bracteato e caudice crasso repente; foliis coriaceis cuneatis vel spathulato-oblanceolatis basi breviter vel in petiolum marginatum angustatis versus apicem argute serratis hirtellis demum glabratis; capitulo pro genere maximo; involucri squamis linearibus; ligulis pallide roseis brevibus discum paullo superantibus; acheniis lanceolatis lævibus, rostro brevi glanduloso. — Top of the mountain of West Maui. — Leaves about 2 inches long, 4 to 6 lines wide. The stout, bracted scape, 5 to 10 inches high, bears a single head 6 to 9 lines in diameter. The leafy bracts of the scape are linear-oblanceolate and usually entire. (M. & B. 440.)

196. ASTER (TRIPOLIUM) DIVARICATUS, Nutt., var. SANDWICENSIS, Gray. *A. subulatus*, Less. in Linnæa, 6, p. 120, non Michx.; Hook. & Arn. Bot. Beech. Voy. p. 87. *Trip. subulatum*, var., DC. Prodr. 5, p. 254. *Erigeron multiflorum*, Hook. & Arn. l. c., ex spec. in herb. Hook. (fide Gray, mss. Bot. S. Pacif. Expl. Exp.).

197. VITTADINIA HUMILIS, Gray, in Proceed. Amer. Acad. 5, p. 118. (M. & B. 516; Remy, 244.)

198. VITTADINIA TENERRIMA, Gray, l. c. p. 119. *Aster tenerrimus*, Less. in Linnæa, 6, p. 120. *Tetramalopium tenerrimum*, Nees.

199. VITTADINIA REMYI, Gray, l. c. (M. & B. 373; Remy, 239.)

200. VITTADINIA CHAMISSONIS, Gray, l. c. p. 119. *Erigeron lepidotum*, Less. in Linnæa, 6, p. 502. *E. pauciflorus*, Hook. & Arn. Bot. Beech. Voy. p. 87. (M. & B. 355.) Var.? ARBUSCULA, Gray, l. c.

201. VITTADINIA CONSANGUINEA, Gray, l. c. p. 120.

202. VITTADINIA ARENARIA, Gray, l. c. p. 120. (M. & B. 519.)

203. VITTADINIA CONYZOIDES, Gray, l. c. (M. & B. 532.) Var. DENTATA: foliis majoribus remote dentatis. (M. & B. 361.)

204.† ERIGERON CANADENSE, Linn. (M. & B.)

205.† FRANSERIA TENUIFOLIA, Gray. (M. & B.)

206.† ACANTHOSPERMUM BRASILUM, Schrank, Pl. Rar. Hort. Monac. t. 53. *A. xanthioides* & *A. hirsutum*, DC. Prodr. 5, p. 522. *Centrospermum xanthioides*, H B K. Nov. Gen. & Spec. 1, p. 271, t. 397.

207.† ECLIPTA ALBA, Hask. Pl. Jav. Rar. p. 528; Miq. Fl. Ind. Bot. 2, p. 65. *E. erecta* & *E. prostrata*, Linn. Mant. p. 216, etc. *E. procumbens* & *brachypoda*, Michx. Fl. 2, p. 129. *Cotula alba*, Linn. Syst. Nat. 2, p. 564, et *Verbesina alba*, L.

208. COREOPSIS MAVIENSIS, Gray, l. c. p. 125. (M. & B. 372; Remy, 289.)

209. COREOPSIS (CAMPYLOTHECA) MACROCARPA, Gray, l. c. p. 126. (W. T. Brigham.)

210. COREOPSIS (CAMPYLOTHECA) MACRÆI, Gray, l. c. p. 126. *Campylotheca grandiflora*, DC. Prodr. 5, p. 293. (Remy, 285.)

211. COREOPSIS (CAMPYLOTHECA) COSMOIDES, Gray, l. c. p. 126. (M. & B. 537; Remy, 278.) A large suffruticose species, the elongated herbaceous branches erect and spreading five to eight feet. The heads always pendent at the ends of the naked peduncles, two inches in diameter, and very showy.

212. COREOPSIS (CAMPYLOTHECA) MENZIESII, Gray, l. c. p. 127. *Campylotheca australis*, Less. pro parte? (M. & B. 520; Remy, 290.)

213. Coreopsis (Campylotheca) micrantha, Gray, l. c. p. 127. *Bidens micrantha*, Gaud. l. c. p. 464, t. 85; Hook. & Arn. l. c. *Campylotheca australis*, Less. in Linnæa, 6, p. 509, excl. syn. Forst. & Spreng. *Campylotheca micrantha*, Cass. dict. 51. (M. & B. 450; Remy, 280.)

214. Bidens Sandwicensis, Less. in Linnæa, 6, p. 508. *B. micrantha*, Hook. & Arn. Bot. Beech. Voy. p. 86, non Gaud. l. c. *B. peduncularis*, DC. Prodr. 5, p. 598, non Gaud. l. c. *B. paniculata*, Hook. & Arn. l. c. p. 66. *Adenolepis pulchella*, Less. l. c. p. 511. (M. & B. 541; Remy, 279, 283.) Var. heterophylla, Gray, l. c. p. 128. *B. luxurians*, Hook. & Arn. l. c. p. 86. (Remy, 281.) Var. ovatifolia, Gray, l. c.

215. Bidens Hawaiensis, Gray, l. c. p. 128. (M. & B. 98.)

216.† Bidens pilosa, Linn. (M. & B. 49.)

217.† Bidens chrysanthemoides, Michx. Fl. Bor.-Am. 2, p. 136, non Pursh. *B. helianthoides*, H B K. Nov. Gen. & Sp. 4, p. 230. *B. quadriaristata*, DC. Prodr. 5, p. 595. (Remy, 258bis.)

218. Lipochæta australis, Gray, l. c. p. 129. *Lipotriche australis*, Less. Var. connata, Gray, l. c. *Verbesina connata*, Gaud. Bot. Freyc. Voy. p. 464. *Lipochæta connata*, DC. Prodr. 5, p. 611. (Remy, 271.) Var. decurrens, Gray, l. c. *Microchæta lanceolata*, Nutt. in Trans. Am. Phil. Soc. 7, p. 451. (M. & B. 375, 540, 542.) Var. lobata, Gray, l. c. p. 130. *Verbesina lobata*, Gaud. l. c. p. 464; Hook. & Arn. Bot. Beech. Voy. p. 87. *V. hastulata*, H. & A. l. c. *Lipochæta lobata* & *hastulata*, DC. Prodr. 5, p. 611. (Remy, 273.)

219. Lipochæta subcordata, Gray, l. c. p. 130.

220. Lipochæta calycosa, Gray, l. c. p. 130.

221. Lipochæta lavarum, DC. Prodr. 5, p. 611; Gray, l. c. p. 130. *Verbesina lavarum*, Gaud. Bot. Freyc. Voy. p. 464. (M. & B. 358, 374; Remy, 277.)

222. Lipochæta integrifolia, Gray, l. c. p. 130. *Microchæta integrifolia*, Nutt. in Trans. Am. Phil. Soc. 7, p. 451. (M. & B. 371; Remy, 255.)

223. Lipochæta succulenta, DC. Prodr. 5, p. 611. Gray, l. c. p. 130. *Verbesina succulenta*, Hook. & Arn. Bot. Beech. Voy. p. 87. (Remy, 257, 258.)

224. Lipochæta heterophylla, Gray, l. c. (M. & B. 359.)

225. Lipochæta tenuifolia, Gray, l. c. p. 131. (M. & B. 534; Remy, 276.)

226. Lipochæta micrantha, Gray, l. c. p. 131. *Schizophyllum*

micranthum, Nutt. in Trans. Am. Phil. Soc. 7, p. 453. *Aphanopappus Nuttallii*, Walp. Rep. 2, p. 620. (M. & B. 536; Remy, 245.)

227. LIPOCHÆTA REMYI, Gray, l. c. p. 131. (M. & B. 533; Remy, 260.)

228. ARGYROXIPHIUM SANDWICENSE, DC. Prodr. 5, p. 668; Gray, l. c. p. 136. (Remy, 254.)

229. ARGYROXIPHIUM MACROCEPHALUM, Gray, in Proceed. Amer. Acad. 2, p. 160, & 5, p. 137. — The tuft of linear silvery-pubescent leaves from the short and thick stem is sometimes as much as four feet in diameter, and the compound branching panicle arising from their midst, six or eight feet high, bears innumerable heads of flowers, which are yellow in the disk and purple in the ray. (M. & B.)

230. WILKESIA GYMNOXIPHIUM, Gray, l. c. 5, p. 136. — This looks much like an *Argyroxiphium* raised upon a stem 6 or 8 feet high. The leaves are Yucca-like, whorled, and their connate cup-like bases overlapping one another from below upwards. The compound panicle is one to three feet long, bearing small yellow heads, about half an inch in diameter, on very slender peduncles and pedicels. — Only found on the dry southwestern slopes of the mountain of Kauai. (M. & B. 535.)

231. DUBAUTIA PLANTAGINEA, Gaud. Bot. Freyc. Voy. p. 469, t. 84; Gray, l. c. p. 134. (M. & B. 365; Remy, 237.) Var. LÆVIGATA. *D. lævigata*, Gray, l. c. p. 135. (M. & B. 538.)

232. DUBAUTIA LAXA, Hook. & Arn. Bot. Beech. Voy. p. 87; Gray, l. c. p. 135. (M. & B. 133; Remy, 238.)

233. DUBAUTIA PALEATA, Gray, l. c. p. 135.

234. RAILLARDIA LATIFOLIA, Gray, l. c. p. 132. (H. Mann.)

235. RAILLARDIA SCABRA, DC. Prodr. 6, p. 441; Gray, l. c. p. 133. (M. & B. 366; Remy, 248, 249.)

236. RAILLARDIA LAXIFLORA, DC. Prodr. 6, p. 441; Gray, l. c. p. 133. (Remy, 250; W. T. Brigham.)

237. RAILLARDIA CILIOLATA, DC. Prodr. 6, p. 441; Gray, l. c. p. 133. (M. & B. 517, 518; Remy, 247, 251, 252, 253.)

238. RAILLARDIA HILLEBRANDI (sp. nov.): ramis pubescentibus; foliis ternatis confertiusculis ovatis oblongisve acutis basi subamplexicauli sessilibus trinerviis pubescentibus; paniculis folioso-bracteatis; capitulis elongatis 4–5-floris. — Waimea, Hawaii (U. S. Expl. Exped.; Hillebrand, no. 14). Differs from *R. linearis* in its heads not being cymosely-fascicled, in their larger size, and in the broader and pubescent sessile leaves.

239. Raillardia linearis, Gaud. Bot. Freyc. Voy. p. 469, t. 83; DC. Prodr. 6, p. 440. Gray, l. c. p. 133. (M. & B. 356.)

240. Raillardia Menziesii, Gray, l. c. p. 133. (M. & B. 367.)

241. Raillardia platyphylla, Gray, l. c. p. 134.

242. Raillardia arborea, Gray, l. c. p. 134.

243. Raillardia montana (sp. nov.): fruticosa, orgyalis; ramis patentibus confertiuscule foliaceis; foliis patentibus lanceolato-oblongis acutis 5-nerviis glabris vel minute pubescentibus denticulatis sessilibus plerisque alternis; panicula subsimplici; capitulis longe pedicellatis 15-23-floris. *R. arborea*, var. foliis angustioribus, Gray, in herb. — Hualalai, Hawaii, at 6,000 feet elevation. — A much-branched shrub, differing from the preceding species in its manner of growth, in the thinner leaves, which are smoother, and not closely imbricated; from *R. platyphylla* by its narrower leaves with fewer veins, etc. (M. & B. 521.)

244. Raillardia struthioloides, Gray, l. c. p. 134.

245. Artemisia australis, Less. in Linnæa, 6, p. 522; Gray, l. c. p. 137. Var. Eschscholtziana, Gray, l. c. (M. & B. 539.) Var. Mauiensis, Gray, l. c. Var. microcephala, Gray, in herb. (Hillebrand.) — In favorable situations a large shrub, 6 feet high, branching from the base.

246. Gnaphalium luteo-album, Linn. *G. Sandwicensium*, Gaud. Bot. Freyc. Voy. p. 466, fide Gray. (M. & B. 309; Remy, 236.)

247. Senecio Sandwicensis, Less. in Linnæa, 6, p. 526; DC. Prodr. 6, p. 375.

248.† Centaurea Melitensis, Linn. (M. & B. 3; Remy, 294.)

249. Hesperomannia arborescens, Gray, in Proceed. Amer. Acad. 6, p. 554. — The only known *Labiatiflora* from any of the proper Pacific Islands. The genus belongs to the group *Flotowieæ* of Weddell's arrangement of the *Mutisiaceæ;* and is related to *Chuquiraga* and *Doniophyton* on the one hand, and to *Stiftia* and *Anastraphia* on the other. A small tree, about 20 feet high, and divaricately branched, bearing several flower-heads at the ends of the branches. Leaves 3 to 5 inches long, 1 to 1½ inches wide, near the ends of the branches; the heads are 1½ to 2 inches in diameter, with bright yellow flowers and tawny pappus. — Only one tree seen, on the summit of Lanai, at about 2,500 feet elevation. (M. & B. 357.)

250.† Sonchus asper, Linn.

251.† Youngia Japonica, DC. Prodr. 8, p. 149. *Prenanthes Japonica*, Linn. *Crepis Japonica*, Benth. (M. & B. 244.)

Lobeliaceæ.

ROLLANDIA, *Gaud. Bot. Freyc. Voy. p.* 458.*

Calyx tubo ovoideo, lobis abbreviatis æqualibus. Corolla arcuato-gibbosa, a latere compressa, tubo integro superne inflato dorso fisso, calyce multo longiore, limbo quinquepartito subbilabiato, lobis lanceolatis. Columna staminea inferne corollæ postice et lateraliter adnata. Antheræ duæ inferiores barbatæ. Stigma bilobum. Bacca bilocularis, calyce diu persistente coronata. — Frutices lactescentes, Sandwicenses, racemis axillaribus brevibus, pedicellis nudis. Folia integra, sesqui-tripedalia.

252. ROLLANDIA LANCEOLATA (Gaud. l. c.): fruticosa; foliis oblongo-lanceolatis duplicato-dentatis subtus hirtellis utrinque acutis, petiolis sesqui-bipollicaribus; pedunculis petiolo subæquilongis paucifloris; calycis lobis glabris obovatis obtusis tubo ovoideo triplo brevioribus; columna staminea antherisque hirsutis; corolla fere glabra; stigmate nudo; semina minutissime striato-reticulata. — *R. lanceolata*, & var. *grandifolia*, DC. Prodr. 7, p. 344. *R. Delessertiana*, Gaud. Bot. Bonite, t. 75. *Delissea lanceolata*, Gray, in Proceed. Amer. Acad. 5, p. 147. — Oahu. (W. T. Brigham.)

253. ROLLANDIA CRISPA (Gaud. l. c.): fruticosa; foliis obovato-lanceolatis inferne longe attenuatis breviter petiolatis membranaceis fere glabris margine serrulatis undulatis vel integerrimis; pedunculo petiolum adæquante paucifloro; calycis lobis oblongis obtusis subfoliaceis velutinis valde imbricatis ovario æquilongis; columna staminea glabra; corolla cinereo-puberula; stigmate nudo. — *Cyanea? Rollandia*, Gray, l. c. p. 149. — Oahu. (M. & B. 58.)

254. ROLLANDIA HUMBOLDTIANA (Gaud. Bot. Bonite, t. 76): fru-

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* The diagnostic characters of the four fleshy-fruited genera of Lobeliaceæ peculiar to the Hawaiian Islands may be stated thus: —

ROLLANDIA. Calycis lobi breves. Corolla arcuato-gibbosa a latere compressa. Columna staminea corollæ postice et lateraliter adnata. Caudex fere herbaceus.

DELISSEA. Calycis lobi breves seu brevissimi, sæpius dentiformes. Corolla arcuata, tubo cylindraceo. Columna staminea libera. Arbusculæ columnæformes vel ramosæ.

CYANEA. Calycis lobi foliacei vel prælongi. Corolla arcuata vel rectiuscula. Columna staminea libera. Frutices vel arbores columnæformes.

CLERMONTIA. Calycis lobi corollam æquilongam sub anthesi valvatim includentes, caduci. Columna staminea libera. Arbusculæ ramosæ.

ticosa; foliis lanceolatis vel obovato-lanceolatis inferne attenuatis longiuscule petiolatis fere glabris serrulatis vel integerrimis; pedunculo petiolum adæquante vel superante paucifloro; floribus hirtellis; calycis lobis lanceolatis ovario dimidio brevioribus; columna staminea glabra; stigmate pilis cincto. — Oahu. (W. T. Brigham.) — I have fortunately been able to identify a single specimen, which Mr. Brigham collected, with the figure of this species: as is shown by the description, drawn from the specimen, aided by Gaudichaud's excellent figure, it has characters of value upon which to stand.

DELISSEA, *Gaud. Bot. Freyc. Voy. p.* 459.

Calyx tubo hæmispherico vel turbinato, lobis brevibus sæpius dentiformibus. Corolla arcuata, tubulosa, bilabiata, tubo sæpius dorso fisso, labiis longitudine æqualibus. Columna staminea a corolla libera. Antheræ duæ inferiores barbatæ. Stigma bilobum. Bacca subglobosa, bilocularis. — Frutices vel arbusculæ lactescentes, Sandwicenses, foliis integris vel pinnatifidis, racemis axillaribus, pedicellis sæpe bibracteolatis.

255. DELISSEA CLERMONTIOIDES (Gaud. Bot. Bonite, t. 47): fruticosa, hirtella; foliis coriaceis oblongis utrinque acuminatis creberrime serrulatis supra glabris breviter petiolatis; pedunculis bracteatis paucifloris petiolum adæquantibus vel superantibus; pedicellis pedunculo æquilongis bibracteolatis; lobis calycis brevissimis triangularibus; corolla bipollicari sub-bilabiata; bacca angulato-sphærica apice truncata (pollicari); seminum testa lævissima. — Gray, l. c. p. 147. — This character has been drawn up from a young specimen in the collection of the United States Exploring Expedition, helped out by Gaudichaud's figure.

256. DELISSEA CORIACEA (Gray, l. c. p. 147): "fruticosa, glabra; foliis amplis (pedalibus et ultra) oblongo-lanceolatis coriaceis repando-serrulatis basi acutis longiuscule petiolatis, venulis conspicue reticulatis; racemis plurifloris petiolum haud superantibus; calycis limbo obsoleto seu dentibus 5 minutis instructo; corolla (glabra) pollicari subcurvata." — Kauai. (Remy, 302.)

Var.? β. "foliis spathulato-lanceolatis in petiolum brevem longe attenuatis." — Fruit as large as a cherry. — Haleakala, East Maui. This may be my *D. arborea.*

Var.? γ. PINNATILOBA (Gray, l. c. & in Bot. S. P. Expl. Exped. ined.): "foliis profunde sinuato-pinnatifidis, lobis utrinque 5–7 obtu-

sissimis integerrimis." — Mountains of Kauai. This was doubtfully referred by Gray to *D. Delessertiana*, Gray, l. c., which is *Rollandia Delessertiana*, Gaud. Bot. Bonite, t. 75, which again appears to be identical with *R. lanceolata*, Gaud. I have little doubt that it is a variety of *D. coriacea*, but only some leaves have been collected.

257. DELISSEA OBTUSA (Gray, l. c. p. 148): "fruticosa; ramis junioribus floribusque undique pubescentibus; foliis (5–8-pollic.) membranaceis oblongis serrulatis apice vel utrinque obtusis subtus parce pubescentibus; racemis plurifloris petiolum gracilem haud superantibus; calycis limbo minuto vel fere obsoleto; corolla gracili subpollicari incurva"; columna staminea glabra; seminum testa lævissima nitidiuscula. — Mountains of Maui. (M. & B. 466.)

Var. MOLLIS (Gray, l. c.): "caule crassiori; foliis elongatis (subpedalibus) oblongo-lanceolatis basi in petiolum breviusculum attenuatis supra puberulis subtus molliter pubescentibus; floribus pollicaribus crassiusculis cæruleis." — Mouna Kea, Hawaii.

258. DELISSEA HIRTELLA (sp. nov.): fruticosa, ramosa, hirtella; foliis oblanceolatis utrinque acuminatis crebre serrulatis supra glabris petiolatis; pedunculis paucifloris petiolo brevioribus; lobis calycis lanceolatis ovario multo brevioribus. — Mountains above Waimea, Kauai. — A large branching shrub, 20 feet high, hirsute with short rusty hairs. Leaves 7 to 10 inches long, 2 to 3 wide. Petioles about 2 inches long. Only flower-buds seen, in which the sepals are scarcely a line long. (M. & B. 574.)

259. DELISSEA ACUMINATA (Gaud. Bot. Freyc. Voy. p. 475, t. 76; DC. Prodr. 7, p. 342, non Gray, l. c. p. 148): fruticosa, ramosa; foliis oblongis utrinque acuminatis denticulatis membranaceis pilosiusculis subtus pallidioribus longiuscule petiolatis; pedunculis petiolo brevioribus; pedicellis filiformibus nudis, floribus racemosis; calycis lobis lanceolatis puberulis ovario dimidio brevioribus; corolla (12–16 lin. longa) glabrata; columna staminea hirtella; seminum testa lævissima flava. — Oahu. (M. & B. 233.)

260. DELISSEA ANGUSTIFOLIA (Presl, Prodr. Lob. p. 47): fruticosa, ramosa; foliis lanceolatis acutis serratis, serraturis obtusis, petiolis limbo dimidio brevioribus; pedunculis axillaribus plurifloris petiolo æquilongis; floribus corymbosis; pedicellis filiformibus nudis; calycis lobis dentiformibus ciliolatis caducis; corolla cum columna staminea glabra; seminum testa lævissima nitidiuscula. — DC. Prodr. 7, p. 343. *D. acuminata*, & var. *angustifolia*, Gray, l. c. p. 148. *Lobelia angus-*

tifolia, Cham. in Linnæa, 8, p. 219. — Oahu. (M. & B. 231; Remy, 299.)

261. Delissea rhytidosperma (sp. nov.): arborescens; foliis lanceolatis petiolatis membranaceis utrinque acuminatis serratis, serraturis acutis; pedunculis axillaribus paucifloris petiolo brevioribus; floribus racemosis; pedicellis nudis; calycis lobis dentiformibus persistentibus; seminum testa valde undulato-rugosa. — Mountains above Waimea, Kauai. — A small tree, glabrous in all parts as far as known. Leaves 3 to 5 inches long, 1 to 1¼ inches wide, thin and somewhat reticulated-veiny. Petioles an inch long or less. Peduncles quite short. The persistent calyx-lobes less than half a line long. Flowers unknown. (M. & B. 576.)

262. Delissea arborea (sp. nov.): caule simplicissimo fere glabro; foliis bipedalibus subcoriaceis oblanceolatis superne creberrime serrulatis inferne longe gradatim attenuatis integerrimis sessilibus; pedunculis axillaribus brevibus paucifloris; calycis limbo fere obsoleto; corolla alba fere recta. — Ulapalakua, E. Maui. — Trunk simple, erect, 20 feet high, bearing a large tuft of horizontally spreading leaves at the apex, among the sessile bases of which are the short-peduncled clusters of flowers. (M. & B. 461.)

263. Delissea subcordata (Gaud. Bot. Freyc. Voy. p. 457, t. 77): fruticosa, ramosa, glaberrima; foliis ovatis subcordatis acutis inæqualiter serratis, dentibus acutis, petiolo limbo æquilongo; pedunculis petiolo æquilongis vel brevioribus; pedicellis nudis; calycis lobis brevissimis pilosiusculis; corolla (sesquipollicari) dorso ad medium fissa; bacca turbinata; seminum testa eximie rugosa. — DC. Prodr. 7, p. 342. *D. undulata*, Gray, l. c. p. 148, pro parte. — Kaala Mountains, Oahu; Kauai. (M. & B. 573.)

264. Delissea undulata (Gaud. Bot. Freyc. Voy. p. 457, t. 78): fruticosa; caule simplicissimo glaberrimo; foliis ovato-lanceolatis acutis serratis in petiolum limbo dimidio breviorem v. æquilongum angustatis, nunc subcordatis; pedunculis brevibus confertis plurifloris; pedicellis nudis; calycis lobis brevissimis; corolla (subpollicari) dorso ad medium usque fissa; bacca ovoidea; seminum testa læviuscula. — "Kauai" or more probably "Niihau" (Remy, 300bis), where it was also found by Mr. W. T. Brigham.

265. Delissea platyphylla (Gray, l. c. p. 148): caule fruticoso orgyali petiolisque tuberculis aculeisve conicis mollibus obsitis; foliis sesquipedalibus obovato-oblongis repandis membranaceis glabris petio-

latis; pedunculis axillaribus brevibus crassis paucifloris; pedicellis sub-pollicaribus nudis; lobis calycis brevibus subulatis; floribus fere bipollicaribus. — Puna, Hawaii, in woods near Hilo. (M. & B.)

266. DELISSEA RACEMOSA (sp. nov.): fruticosa; foliis oblongo-lanceolatis vel ovato-lanceolatis utrinque acutis minute eroso-crenulatis in petiolum brevem longe attenuatis, supra pilis conicis brevibus raris, subtus albidis pubescentibus venis brunneis; pedunculis folium adæquantibus bracteatis; pedicellis bracteolatis; calycis lobis glabratis oblongis obtusiusculis ovario multo brevioribus. — Oahu. — An unbranched shrub, 5 or 6 feet high. Leaves a foot long, about 4 inches wide, tapering gradually at the base into a petiole but an inch long. The pubescence on the under surface of the leaf whitish, except on the brown veins, and quite characteristic. Peduncles loosely several-flowered. Ovary 6 or 7 lines long. Sepals hardly exceeding a line in length. (M. & B.)

267. DELISSEA CALYCINA (Presl. Prodr. Lob. p. 47): foliis oblongo-lanceolatis utrinque acutis in petiolum brevem longe attenuatis inæqualiter eroso-crenulatis supra planis pilisque conicis brevibus raris sparsis conspersis subtus reticulato-venosis in rete fuscescente præsertim hirtis; calyce glabro, lobis oblongis obtusiusculis uninerviis; ovario sub anthesi obconico, grossificatione olivæformi, vertice lobis calycis erectis coronato; corolla limbo hirtella; tubo antherarum circa basin sursumque in sulcis hirto. *Lobelia calycina*, Cham. in Linnæa, 8, p. 222. — Leaves crenulate, shining above, $1\frac{1}{2}$ feet long, 3 inches wide. Petiole 1 inch long. In some notes which Prof. A. Braun has obligingly communicated concerning Chamisso's specimen of this plant in the Berlin herbarium, he shows that the common peduncle is but an inch or two long, much thickened, and that the sepals are ovate-lanceolate, 3 lines long and half as wide. It thus differs in several respects from the preceding species, which I had at first thought should be referred here, but I am not so sure now that this species should not stand in *Cyanea*, and near *C. aspera*, Gray.

268. DELISSEA PINNATIFIDA (Presl. l. c. p. 47): ramosa; foliis oblongo-lanceolatis utrinque acutis in petiolum brevem decurrentibus remote pinnatifidis leviter sinuato-duplicato-dentatis, dentibus brevibus pinnisque obtusis calloso-mucronulatis, supra planis glabris, subtus reticulato-venosis in rete fuscescente præsertim hirtis; racemis axillaribus; calycibus corollisque hirtis; ovario obconico lobis calycis auriculatis ovatis obtusis coronato. *Lobelia pinnatifida*, Cham. in Linnæa, 8, p. 220. — Oahu.

269. Delissea ambigua (Presl. l. c. p. 47): foliis oblongo-lanceolatis utrinque acutis in petiolum brevem longe angustatis sinuato-duplicato-triplicatoque-dentatis (dentibus calloso-mucronulatis) supra planis glabris subtus hirtis reticulato-venosis rete fuscescente; racemis axillaribus; ovario obconico glabrescente; lobis calycis ovatis subemarginato-obtusis mucronatis paululum hirtellis; corolla in nervis præsertim hirta. *Presl.* — According to Chamisso, perhaps not distinct from the preceding, but the calyx-lobes less auricled, etc. *Lobelia ambigua*, Cham. l. c. p. 221. — I know nothing of this or the preceding species. Perhaps they should stand in *Cyanea.*

270. Delissea Mannii (W. T. Brigham, in litt.): fruticosa, ramosa, puberula; foliis lanceolatis acutis serratis subtus pallidioribus; pedunculis petiolo subæquilongis pollicaribus; calycis lobis linearibus ovario bis longioribus; corolla fere recta; seminum testa minutissime striato-reticulata. — Molokai. — Leaves 5 or 6 inches long, 1 to 1½ inches wide. Calyx lobes 3 or 4 lines long, less than a line wide. (W. T. Brigham.)

271. Delissea fissa (sp. nov.): fruticosa, ramosa; foliis sesquipedalibus in petiolum longe attenuatis obovato-lanceolatis utrinque præsertim basi acuminatis crenatis supra glaberrimis subtus parce hirsutulis; racemis brevibus 8–12-floris; pedunculis pedicellisque bracteolatis cum floribus (sesquipollicaribus) glanduloso-villosis; lobis calycis lanceolatis ovario longioribus; corolla purpurea dorso usque ad basim fissa; columna staminea glaberrima. — Valleys of Kealia and Hanalei, Kauai. — A branching shrub about 10 or 12 feet high. (M. & B. 577.)

272. Delissea pilosa: "caule frutescente; foliis subpedalibus membranaceis obovatis utrinque acutis vel acuminatis eroso-crenatis pilis brevibus mollibus hirsutis; racemis brevibus in pedunculo 1–2-pollicari hirsutissimo paucifloris; floribus parvis griseo-cæruleis pedicellisque glabris; lobis calycis linearibus [subfoliaceis] ovario oblongo æquilongis." — *Cyanea pilosa*, Gray, l. c. p. 149. — Mauna Kea, Hawaii.

273. Delissea asplenifolia (sp. nov.): fruticosa, fere glabra; foliis membranaceis amplis (ultrapedalibus) pinnatisectis; segmentis lanceolatis sinuato-subpinnatifidis ala sinuata confluentibus; costa rhachi petiolisque plurifloris aculeis brevibus armatis; pedicellis bracteolatis; lobis calycis oblongis obtusiusculis ovario dimidio brevioribus; corolla gracili fere bipollicari. — Waiehu Valley, West Maui. — A

small simple-stemmed shrub 3 to 5 feet high. Leaves much like those of *Cyanea Grimesiana*. (M. & B. 464.)

CYANEA, *Gaud. Bot. Freyc. Voy. p.* 457.

Calyx profunde 5-fidus, tubo turbinato, lobis æqualibus foliaceis persistentibus. Corolla tubulosa, subarcuata, 5-fida, dorso ad medium vel basim usque fissa, lobis sub-bilabiatis æquilongis lineari-lanceolatis. Columna staminea a corolla libera. Antheræ duæ inferiores vel omnes barbatæ. Stigma bilobum. Bacca bilocularis. — Frutices vel arbores lactescentes, Sandwicenses, sæpius tuberculato-aculeatæ, foliis integris vel pinnatipartitis, racemis axillaribus.

274. CYANEA ASPERA (Gray, l. c. p. 148): "foliis oblongo-ovatis acuminatis denticulatis subtus ad venas venulasque ochraceo-hirtellis utrinque setulis basi papillatis asperis, petiolo muricato; calycis glabri lobis ovalibus obtusissimis foliaceis tubum elongato-obconicum æquantibus; corolla $2\frac{1}{2}$-pollicari curvata." — Oahu. (Expl. Exp.)

275. CYANEA ARBORESCENS (sp. nov.): ramosa, glabra; foliis coriaceis obtusis basi angustatis crebre repando-serrulatis supra viridissimis subtus pallidioribus; pedunculis axillaribus paucifloris; bacca flava diametro sesquipollicari; lobis calycis succulentis pollicaribus vel sesquipollicaribus oblongis obtusis. — West Maui. — A small tree 20 or 25 feet high, much branched. Leaves 3 to 6 inches long, 1 to $1\frac{1}{2}$ inches wide. Fully expanded flowers not seen, but the young bud an inch long. (M. & B.; Hillebrand?)

276. CYANEA LOBATA (sp. nov.): fruticosa, glabra; foliis sesquipedalibus oblanceolatis obtusis inæqualiter sinuato-lobatis subtus pilis brevibus rarissimis (petiolo 3 – 4-pollicari aculeis conicis sparsis) obsitis; pedunculis bracteatis paucifloris petiolo subæquilongis, bracteis linearibus subfoliaceis; sepalis foliaceis late oblongis obtusis mucronatis plurinerviis pollicaribus ovario multo longioribus; corolla magis curvata 2 – 3-pollicari; stigmate valde bilobo nudo. — West Maui. — A small shrub. (M. & B. 467.)

277. CYANEA GRIMESIANA (Gaud. Bot. Freyc. Voy. p. 4, t. 75): fruticosa, glabra; foliis cum petiolo 6-pollicari bi – tripedalibus pinnatisectis, segmentis lanceolatis sinuatis; petiolis aculeis conicis armatis; pedunculis longis laxe paucifloris pluribracteatis, bracteis lanceolatis foliaceis; pedicellis bipollicaribus bracteolatis; lobis calycis oblongis acuminatis foliaceis plurinerviis ultrapollicaribus ovario longioribus; corolla curvata 2 – 3-pollicari; stigmate bilobo pilis cincto; bacca longe turbinata. — Oahu. (M. & B. 201.)

Var.? CITRULLIFOLIA (Gray, l. c. p. 148): "foliis bipinnatipartitis, segmentis sinuatis; caule aculeis conicis creberrimis horrido." — Hawaii. Oahu.

278. CYANEA LEPTOSTEGIA (Gray, l. c. p. 149): "glabra; foliis ad apicem caulis simplicis arborei confertis lanceolatis subsessilibus integerrimis undulatis (bipedalibus et ultra); racemis brevissimis confertifloris; calycis segmentis prælongis e basi latiori angustissime linearibus patentibus corolla gracili longioribus persistentibus." — Mountains above Waimea, Kauai. — A very remarkable-looking plant, the erect columnar trunk 30 or 40 feet high, bearing at its apex a dense spreading tuft of leaves. Flowers dark purple. (M. & B. 575.)

279. CYANEA TRITOMANTHA (Gray, l. c. p. 149): "caule simplici arborescente orgyali; foliis lato-lanceolatis membranaceis subintegerrimis fere glabri basi acutis tripedalibus (incl. petiolo crasso 5 – 8-pollicari); floribus confertis magnis; calyce pubescente, lobis linearibus pollicaribus foliaceis ovario cylindraceo longioribus; corolla tripollicari extus tomentoso-pubescente in segmenta 3 longo-linearia mox divisa." — Mouna Kea, Hawaii. (Expl. Exp.)

280. CYANEA SUPERBA (Gray, l. c. p. 149): caule arborea simplicissima; foliis ad apicem caulis confertis lanceolatis eroso-crenulatis subcoriaceis bi – tripedalibus petiolatis; inflorescentia corollisque tomentosis; pedunculis elongatis nutantibus crebre bracteatis capitulo compacto globoso terminatis; lobis calycis oblongis foliaceis (margine imbricatis?); corolla bipollicari tubulosa unilabiata, laciniis linearibus patentibus. — *Macrochilus superbus*, Presl. Prodr. Lob. p. 47. *Lobelia superba*, Cham. in Linnæa, 8, p. 223, 225. — Seen growing on the Kaala Mountains, Oahu, but unfortunately not in flower.

CLERMONTIA, *Gaud. Bot. Freyc. Voy. p.* 459.

Calyx coloratus, supra ovarium productus, arcuatus, corollam æquilongam sub anthesi valvatim includens, ab ovario circumcisse caducus. Corolla tubulosa, arcuata, semi-quinquefida dorso ad basim usque fissa, lobis subæqualibus. Columna staminea a corolla libera. Antheræ 2 inferiores barbatæ. Stigma bilobum. Bacca subglobosa, bilocularis. — Arbusculæ lactescentes, Sandwicenses, foliis integris, racemis axillaribus, pedicellis bibracteolatis.

281. CLERMONTIA GRANDIFLORA, Gaud. Bot. Freyc. Voy. p. 459, t. 73; Gray, l. c. p. 150. Var. BREVIFOLIA, Gray, l. c. Var. OBLONGIFOLIA, Gray, l. c. *C. persicæfolia* et *C. oblongifolia*, Gaud.

l. c. t. 71, 72. Var. LONGIFOLIA, Gray, l. c. *C. grandiflora*, Hook. & Arn. Bot. Beech. Voy. p. 88. *C. Kakeana*, Meyen, in Presl, Lob. *C. macrophylla*, Nutt. *C. macrocarpa*, Gaud. Bot. Voy. Bonite, t. 49. Though variable in the leaves, and in a lesser degree in the flowers, this is a well-marked species, at once recognized wherever seen in the mountain forests which it inhabits, and of which it at times almost forms a part, as it is a large, much-branched shrub or small tree, 10 to 30 feet high. (M. & B. 232.)

282. CLERMONTIA PARVIFLORA, Gaud.; Gray, l. c. p. 150. *C. oblongifolia*, Hook. & Arn. l. c., non Gaud. A small branching shrub. (M. & B. 296.)

BRIGHAMIA, *Gray, nov. gen.*

"Calyx tubo oblongo eximie 10-costato, dentibus parvulis. Corolla hypocraterimorpha; tubo prælongo fere recto antice sinubus 2 profundius fisso; lobis ovato-oblongis æqualiter patentibus consimilibus, nisi 2 anticis longiter unguiculatis. Columna staminea corollæ tubo infra medium (postice altius) adnata; synanthera subinclusa apice recurvo barbata. Ovarium biloculare. Stigma bilobum, nudum. Capsula primum carnosa, loculis demum rimis 2 longitudinaliter dehiscentibus. Semina oblonga; testa tenuiter crustacea læviuscula: embryo rectus albumine oleoso brevior.—Arbuscula Sandwicensis, carnosa, glabra; caule orgyali simplicissimo folia obovata subintegerrima creberrime quasi capitatim conferta gerente; pedunculis axillaribus folio brevioribus apice racemoso-paucifloris; floribus pedicello recto haud resupinatis albis.

283. "BRIGHAMIA INSIGINIS.—Molokai. (W. T. Brigham.) 'Kauai or Niihau.' (Remy, 309[ter].)—Stem 5 to 18 feet high. Leaves (in the specimens) only 6 or 8 inches long, contracted at the base into a very short petiole, evidently more or less fleshy, and forming a close tuft at the summit of the columnar stem. Peduncles stout and manifestly fleshy, 3 to 5 inches long; the thick ascending pedicels half an inch or an inch long: bracts deciduous. Calyx-teeth much shorter than the tube, oblong-linear, slightly accrescent and persistent on the ripe fruit collected by Mr. Brigham, deciduous from that of Remy's specimen. Corolla showy, white with a tinge of cream-color; the rather slender tube about 4 inches long, slightly incurved; the 5 lobes when expanded about an inch long, thickish, valvate in æstivation, with the pointed tips inflexed, in equality of size and position apparently as nearly regular as in *Isotoma*, but the two anterior lobes separated from

each other and from the lateral ones by sinuses, forming narrow claws of nearly the same length as the lobe. The anther-tube half an inch long, scarcely projecting beyond the cleft of the corolla, straight, with the apex abruptly curved toward the upper side of the flower, and tipped with a uniform tuft of beard, otherwise glabrous. Stigma neither bearded nor indusiate, of two small and flat rounded lobes. Ovary acutely and nearly equably 10-ribbed. Fruit three fourths of an inch long, fleshy-coriaceous, 10-ribbed, evidently capsular; each cell opening by two equidistant, longitudinal, intercostal chinks or clefts extending from just below the apex to the base. Seeds very numerous, half a line long. — Described from a specimen in Remy's collection, communicated by the Paris Museum, and from flowers and fruits collected by Mr. Brigham, and preserved in alcohol. — This very interesting addition to the peculiar Lobeliaceæ of the Sandwich Islands, I have dedicated to Mr. Mann's companion in Hawaiian exploration, WILLIAM T. BRIGHAM, Esq., who not only, after M. Remy, discovered it, and brought the materials needful to complete its characters, but who has paid particular attention to this group of plants, collecting specimens, and especially making sketches of the arborescent species he met with. The fruit of my specimen from Remy would rather be thought to be baccate; but Mr. Brigham's prove it to be capsular. The resemblance of our plant to *Isotoma* is mainly in the great length and general form of the corolla. But its true relationship is evidently with the unfortunately little-known *Sclerotheca arborea*, A. DC. (*Lobelia arborea*, Forst.) of Tahiti. In that, however, so far as is made out, the corolla is no longer than the foliaceous calyx-lobes, and cleft to the base, and the *capsule opens at the vertex by two round pores*. The one-flowered peduncle is of small moment, as it is bibracteate; and I suppose it is not certain that the flower is resupinate after the manner of the order, although so described by De Candolle. In the present plant there is no torsion of the pedicel, and the odd sepal is anterior. Unless future discoveries invalidate the characters, *Brighamia* and *Sclerotheca* must surely be regarded as distinct, related genera." *A. Gray, mss.*

284. LOBELIA MACROSTACHYS, Hook. & Arn. l. c. p. 88; Gaud. Bot. Voy. Bonite, t. 46; Gray, l. c. p. 150. A shrub with an upright simple stem, 4 to 8 feet high, dividing at the top into a crown of flowering branches, spreading like the arms of a chandelier. When the light pink flowers have expanded, it is an exceedingly showy plant. (M. & B. 463.)

285. Lobelia Gaudichaudii, A. DC. Prodr. 7, p. 384; Gaud. l. c. t. 45; Gray, l. c. Var. Kavaiensis, Gray, l. c. (M. & B. 462.)

286. Lobelia neriifolia, Gray, l. c. p. 150. (M. & B.)

Goodeniaceæ.

287. Scævola sericea, Forst. Prodr. n. 504; Gray, in Proceed. Am. Acad. p. 151. *S. plumerioides*, Nutt. in Trans. Am. Phil. Soc. n. ser. 8, p. 252. (M. & B. 248; Remy, 315.)

288. Scævola coriacea, Nutt. l. c. p. 253; Gray, l. c. p. 151. In the three forms or varieties designated. (M. & B. 388; Remy, 313, 315bis.)

289. Scævola Gaudichaudii, Hook. & Arn. Bot. Beech. Voy. p. 89; DC. Prodr. 7, p. 507; Gray, l. c. p. 151, non *S. Gaudichaudiana*, Cham. *S. montana*, Gaud. in Bot. Freyc. Voy. p. 460, non Labill. *S. Menziesiana*, var. *glabra*, Cham. in Linnæa, 8, p. 227? *Temminckia Gaudichaudii*, De Vriese, Gooden. p. 11. (M. & B. 385; Remy, 314.)

290. Scævola Chamissoniana, Gaud. l. c. p. 461, t. 82; Hook. & Arn. l. c. p. 89; Gray, l. c. p. 152. *S.* (*Chamissoniana*, Gaud.?) *Gaudichaudiana*, Cham. in Linnæa, 8, p. 226. *S. Menziesiana*, Cham. l. c. p. 227, excl. var. *S. ciliata*, G. Don. Syst. 3, p. 128; DC. Prodr. 7, p. 506. *S. ligustrifolia*, Nutt. in Trans. Am. Phil. Soc. l. c. *S. pubescens*, Nutt. l. c. (M. & B. 9; Remy, 310, 311.)

291. Scævola mollis, Hook. & Arn. l. c.; DC. l. c.; Gray, l. c. p. 152. *Temminckia mollis*, De Vriese, Gooden. p. 12, t. 2. (M. & B. 127; Remy, 312.)

292. Scævola glabra, Hook. & Arn. l. c.; DC. l. c.; Gaud. Voy. Bonite, t. 48; Gray, l. c. p. 152. *Camphusia glabra*, De Vriese, l. c. p. 15, t. 1. (M. & B. 122.)

Ericaceæ.

293. Vaccinium reticulatum, Smith, in Rees, Cycl.; Gray, in Proceed. Am. Acad. 5, p. 323. *V. cernuum*, Cham. & Schlecht. in Linnæa, 1, p. 527; Hook. Ic. Pl. t. 87. Var. dentatum, Gray, l. c. *V. dentatum*, Smith, l. c. Var. calycinum, Gray, l. c. *V. calycinum*, Smith, l. c. Var.? lanceolatum, Gray, l. c. (M. & B. 303.)

294. Vaccinium penduliflorum, Gaud. Bot. Freyc. Voy. p. 454, t. 68; Gray, l. c. p. 323. (M. & B. 102.) Var. berberifolium, Gray, l. c. (M. & B. 430.)

Epacrideæ.

295. CYATHODES TAMEIAMEIÆ, Cham. in Linnæa, 1, p. 539; Gray, in Proceed. Am. Acad. 5, p. 325. Var. CHAMISSOI, Gray, l. c. *C. Tameiameiæ*, Cham.; Hook. & Arn. Bot. Beech. Voy. p. 89. Var. BROWNII, Gray, l. c. *C. Banksii*, (Gaud. Bot. Freyc. Voy. p. 98?) & *Macræana*, DC. Prodr. 7, p. 742. (M. & B. 123; Remy, 488.)

296. CYATHODES IMBRICATA, Stschelglew, in Mosc. Bull. 32, p. 10; 1859. *C. Douglasii*, Gray, l. c. p. 325. Var. STRUTHIOLOIDES, Gray, l. c.

Ebenaceæ.

297. MABA SANDWICENSIS, A. DC. Prodr. 8, p. 242; Gray, in Proceed. Am. Acad. 5, p. 327. (M. & B. 124; Remy, 470, 518.)

298. MABA HILLEBRANDII, Seem. Fl. Vitiensis, p. 151. (Hillebrand, 274 in Herb. Kew. ex Seemann, l. c.)

Sapotaceæ.

299. SAPOTA SANDWICENSIS, Gray, in Proceed. Am. Acad. 5, p. 328. (M. & B. 363; Remy, 475, 476, 478.)

Myrsinaceæ.

300. MYRSINE GAUDICHAUDII, A. DC. in Ann. Sc. Nat. sér. 2, 16, p. 85, & Prodr. I much doubt if this is distinct from the next, but have no specimens, authentic or otherwise.

301. MYRSINE LESSERTIANA, A. DC. l. c. p. 85. (M. & B. 614, foliis angustioribus, 207; Remy, 467.)

302. MYRSINE SANDWICENSIS, A. DC. l. c. p. 85. (M. & B. 525; Remy, 468.)

Primulaceæ.

303. LYSIMACHIA HILLEBRANDI, Hook. f. Gray, in Proceed. Am. Acad. 5, p. 328. Var. α. (M. & B. 229.) Var. β. DAPHNOIDES, Gray, l. c. Var. γ. ANGUSTIFOLIA, Gray, l. c. (Remy, 458.)

304. LYSIMACHIA LINEARILOBA, Hook. & Arn. Bot. Voy. p. 268; Gray, l. c. p. 329. (Remy, 459, 460, vars.)

Plantaginaceæ.

305. PLANTAGO PRINCEPS, Cham. & Schlecht. in Linnæa, 1, p. 167; Gray, in Proceed. Am. Acad. 6, p. 54; DC. Prodr. 13, p. 704. *P. Queleneana*, Gaud. in Bot. Freyc. Voy. p. 445, t. 50; Cham. & Schlecht. l. c. p. 186; Hook. & Arn. Bot. Beech. Voy. p. 93; DC. l.

c. p. 700. (M. & B. 85; Remy, 427.) Var. β. LAXIFOLIA, Gray, l. c. Var. γ. HIRTELLA, Gray, l. c. (M. & B. 613.) Var. δ. LONGIBRACTEATA; bracteis ovato-subulatis floribus inferioribus 2 – 3-plo longioribus: cæt. β. — On wet rocks in Waioli valley, Kauai. (M. & B. 612.)

306. PLANTAGO PACHYPHYLLA, Gray, l. c. p. 54. Var. α. MAVIENSIS, Gray, l. c. (M. & B. 428.) Var. β. HAWAIENSIS. Gray, l. c. (Remy, 429.) Var. γ. KAVAIENSIS, Gray, l. c. (M. & B. 439.)

306[a].† PLANTAGO MAJOR, Linn. (M. & B.)

Plumbaginaceæ.

307. PLUMBAGO ZEYLANICA, Linn. (M. & B. 226; Remy, 227.) The natives use the acrid juice of this, as of *Sisyrinchium acre*, for tattooing.

Gesneriaceæ.

308. CYRTANDRA CORDIFOLIA, Gaud. Bot. Freyc. Voy. p. 446, t. 56; Gray, in Proceed. Amer. Acad. 5, p. 350; Hook. & Arn. Bot. Beech. Voy. p. 91. (M. & B. 63.)

309. CYRTANDRA PLATYPHYLLA, Gray, l. c. p. 350.

310. CYRTANDRA PICKERINGII, Gray, l. c. p. 350.

311. CYRTANDRA TRIFLORA, Gaud. l. c. t. 52; Hook. & Arn. l. c. p. 91; Gray, l. c. p. 351. Var. GAUDICHAUDII, ARGUTA, & LYSIOSEPALA, Gray, l. c.

312. CYRTANDRA GRANDIFLORA, Gaud. l. c. t. 55; Hook. & Arn. l. c. p. 91; Gray, l. c. p. 351. The peduncle is one- or sometimes two-flowered; the flowers subtended by two large and foliaceous, somewhat connivent bracts, which are more or less distinctly 3-nerved from the base, and slightly reticulate-veiny, the nerves and veins with a rusty pubescence like that of the leaves. The bracts at once distinctly characterize the species.

313. CYRTANDRA ŒNOBARBA (sp. nov.): humilis, decumbens, subcarnosa; caule petiolisque crassis pilis rigidulis atro-rufis reflexis creberrime barbatis; foliis ovatis vel subcordatis vix acutis denticulatis ad venas præsertim rufo-hirsutis supra glabrescentibus; pedunculis 1 – 2-floris petiolum subæquantibus; calyce oblongo 5-fido barbato, lobis ovato-lanceolatis acuminatis foliaceis corolla pollicari glaberrima cum limbo amplo explanato paullo brevioribus. — Wahiawa falls, and in Waioli Valley, Kauai. — Stems low and spreading, only one or two feet high, somewhat succulent. Leaves thickish, $2\frac{1}{2}$ to $3\frac{1}{2}$ inches long, on very stout petioles (half an inch to 2 inches long) which, like the

stem, are very densely bearded with stiff and reflexed, many-jointed, brownish-red hairs: these are much longer, denser, and more persistent than those of the rest of the plant. The ample foliaceous bracts, characteristic of the related *C. grandiflora*, are here wanting. Corolla fully an inch long, white, the throat ampliate, and the lobes widely spreading. — It is to be regretted that the specimens secured of this remarkable species are scanty and imperfect. (M. & B. 616 pro parte.)

314. Cyrtandra Lessoniana, Gaud. l. c. t. 54; Hook. & Arn. l. c. p. 91; Gray, l. c. p. 351. *C. Hillebrandi*, Oliver, in herb. Gray, is apparently a form of this species with broadly ovate calyx-lobes, which are separated nearly or quite to the base. There is also another form, if it be not a distinct species, with very narrow, almost linear calyx-lobes, which are more or less united, in some cases forming a tubular calyx which is split down on one side, or with a single free lobe; the corolla is arcuate with a broad lip, and the leaves prominently reticulate-veiny beneath. (M. & B. 617, 77 pro parte.)

315. Cyrtandra paludosa, Gaud. l. c.; Hook. & Arn. l. c.; Gray, l. c. Described as glabrous, but showing a soft fulvous pubescence on the young shoots in the more common form of the species, which becomes quite pronounced on the petioles and large veins of the leaves as well, and with something of the character of that of *C. œnobarba*, on a form (probably referable here) from the foot of Wahiawa falls, Kauai, where it is constantly kept moist by the spray.

316. Cyrtandra Garnottiana, Gaud. l. c. t. 53; Hook. & Arn. l. c.; Gray, l. c. (M. & B. 116, 126, 77 pro parte.)

317. Cyrtandra laxiflora (sp. nov.): foliis ovali- seu ovato-oblongis acuminatis argute serratis membranaceis basi plerumque obtusis supra hirsutulis subtus molliter pubescentibus; pedunculis petiolum gracilem adæquantibus laxe cymoso-multifloris; pedicellis filiformibus hirsutis; calyce 5-partito, lobis linearibus corolla cylindrica hirsuta (fere semipollicari) dimidio brevioribus; fructu glabro ovato-globoso.— Waialua Mountains, Oahu. — A well-marked species, resembling *C. Macræi* in foliage and inflorescence; but the leaves are narrower, the larger ones 6 or 7 inches in length by 3 or 4 in breadth; the peduncles are much longer, as also the pedicels, the latter nearly half an inch long, and hirsutely pubescent; the flowers are nearly twice as large and pubescent; the calyx lobes linear and obtuse. Ovary almost glabrous. Immature fruit half an inch long, ovate, inclining to globose. (M. & B. 615.)

318. Cyrtandra Macræi, Gray, l. c. (W. T. Brigham.)

319. Cyrtandra Menziesii, Hook. & Arn. l. c. p. 91, adn.; Gray, l. c. The leaves are apparently always in fours, and obovate-oblanceolate or oblong, with a long tapering or cuneate entire base. (M. & B. 310.)

Solanaceæ.

320. Solanum Nelsoni, Dunal, in DC. Prodr. 13, p. 123?; Gray, in Proceed. Am. Acad. 6, p. 42. (Remy, 442.) Var. thomasiæfolium, Seemann, in Journ. Bot. 1, p. 209.

321. Solanum puberulum, Nutt. mss. in Herb. Mus. Brit., fide Seemann, l. c. — I do not identify this.

322. Solanum Sandwicense, Hook. and Arn. Bot. Beech. Voy. p. 92; Gray, l. c. *S. Sandwicense* & *Woahense*, Dunal, in DC. l. c. (M. & B. 202.) Var? Kavaiense, Gray, l. c.

323. Solanum incompletum, Dunal, in DC. l. c.; Gray l. c. (M. & B. 457, 458; Remy, 451.)

324. Solanum oleraceum, Dunal, in DC. l. c. p. 50.

325.† Solanum aculeatissimum, Jacq. Coll. 1, p. 100, & Ic. Rar. 1, t. 41. *S. xanthocarpum*, Seemann, l. c. p. 206, non Schrad. & Wendl. Sert. Hanov. 1, p. 8, t. 2. (Seem. n. 1721 in Hb. Gray.)

326. Lycium Sandwicense, Gray, l. c. (M. & B. 596, 597.)

327. Nothocestrum latifolium, Gray, l. c. (M. & B. 413.)

328. Nothocestrum longifolium, Gray, l. c. (M. & B. 414.)

329. Nothocestrum breviflorum, Gray, l. c. p. 49.

330. Nothocestrum subcordatum, (sp. nov.): arboreum, fere glabrum; foliis ovatis ellipticisve subcordatis; pedunculis solitariis; corolla 4 – 5-partita extus dense sericea tubo calycis campanulato inæqualiter quadridentato quadrangulato fere duplo longiore; staminibus 4 – 5; bacca globosa. — In ravines of the Kaala Mountains, Oahu. — A tree 20 or 30 feet high. Leaves 2 to 5 inches long, $1\frac{1}{2}$ to 4 inches wide, subcordate or rounded at the base, more or less obtuse at the apex. Calyx 4 to 5 lines long. Corolla yellow, as in *N. longifolium* and *latifolium*. (M. & B. 620.)

331.* Physalis Peruviana, Linn. Spec. 2, p. 1670. (M. & B. 29.)

Scrophulariaceæ.

332. Herpestis Monniera, HBK. (M. & B. 53.)

333.† Scoparia dulcis, Linn. (Seemann, Fl. Vitiensis.)

Labiateæ.

334. Plectranthus parviflorus, Willd. Hort. Berol. 1, t. 65, non R. Br. *Pl. australis*, Hook. & Arn. Bot. Beech. Voy. p. 92, non R. Br.? This is, however, probably nothing more than the true *Pl. australis*, R. Br. Prodr. Fl. N. Holl. p. 506, and if so, will bear the prior name. (M. & B. 41, 84, 293; Remy, 403.)

335. Sphacele hastata, Gray, in Proceed. Am. Acad. 5, p. 341. (M. & B. 401.)

336. Phyllostegia vestita, Benth. in Bot. Reg. sub 1292, & in DC. Prodr. 12, p. 553; Gray, l. c. p. 342. *P. dentata*, Benth. l. c.

337. Phyllostegia grandiflora, Benth. l. c.; Gray, l. c. p. 342. *Prasium macrophyllum*, Gaud. Bot. Freyc. Voy. p. 453, t. 65, fig. 3, non Benth. l. c. (M. & B. 6; Remy, 383.)

338. Phyllostegia brevidens, Gray, l. c. p. 343. Var.? ambigua, Gray, l. c. p. 343.

339. Phyllostegia glabra, Benth. in Linnæa, 6, p. 79, & in Bot. Reg. l. c.; Gray, l. c. p. 343; Hook. & Arn. Bot. Beech. Voy. p. 92. *Prasium glabrum*, Gaud. Bot. Freyc. Voy. p. 452, t. 64. *Phyllostegia Chamissonis*, Benth. in Linnæa, l. c.; Hook. & Arn. l. c.; DC. Prodr. l. c. *P. Macræi*, Benth. in DC. Prodr. l. c. (M. & B. 224, 354; Remy, 385.)

340. Phyllostegia? hirsuta, Benth. in Bot. Reg. & in DC. Prodr. l. c. p. 555; Gray, l. c. p. 344.

341. Phyllostegia parviflora, Benth. in Linnæa, 6, p. 79, & in DC. Prodr. l. c. p. 554; Gray, l. c. p. 344. (M. & B. 553, 554, 405, 404.) Var. Gaudichaudii, Gray, l. c. Var. glabriuscula, Gray, l. c. *P. macrophylla*, Benth. in Bot. Reg. & in DC. Prodr. l. c. p. 554. Var. mollis, Gray, l. c. *P. mollis*, Benth. in Linnæa, 6, p. 79, & in DC. l. c. p. 554.

342. Phyllostegia stachyoides, Gray, l. c. p. 344.

343. Phyllostegia clavata, Benth. in Bot. Reg. & in DC. Prodr. l. c. p. 554; Gray, l. c. p. 344. (M. & B. 415; Remy, 386.)

344. Phyllostegia racemosa, Benth. in Bot. Reg. & in DC. l. c.; Gray, l. c. p. 344. (M. & B. 555?)

345. Phyllostegia haplostachya, Gray, l. c. p. 345. (Remy, 394.) Var. leptostachya, Gray, l. c.

346. Phyllostegia truncata, Gray, l. c. p. 345. (Remy, 395.)

347. PHYLLOSTEGIA FLORIBUNDA, Benth. Lab. p. 653, & in DC, l. c. p. 555; Gray, l. c. p. 345.

348. STENOGYNE MACRANTHA, Benth. in Bot. Reg. l. c. & in DC. Prodr. 12, p. 555. (M. & B. 402.) Var. GRAYI: labio inferiore breviore. *S. macrantha*, Gray, in Proceed. Am. Acad. 5, p. 346. (Remy, 381.)

349. STENOGYNE ROTUNDIFOLIA, Gray, l. c. p. 347. (M. & B. 403.)

350. STENOGYNE CORDATA, Benth. Lab. p. 654, & in DC. l. c.; Gray, l. c. p. 347.

351. STENOGYNE SESSILIS, Benth. Lab. p. 654, & in DC. l. c.; Gray, l. c. Var. β: foliis lævibus; pedicellis calyce (fructifero) æquilongis. (M. & B. 406.)

352. STENOGYNE CALAMINTHOIDES, Gray, l. c. (Remy, 380.)

353. STENOGYNE SCROPHULARIOIDES, Benth. in Bot. Reg. sub t. 1292, & in DC. l. c. p. 556; Gray, l. c. p. 347. Var. β. Gray, l. c. *S. Nelsoni*, Benth. Lab. p. 655. *Phæopsis montana*, Nutt. in herb. Hook. (Remy, 376.) Var. γ: undique hirsuta; foliis grosse dentatis. (Hillebrand, 339.)

354. STENOGYNE PURPUREA (sp. nov.): parce hirsuta, divaricato-ramosa; foliis ovato-lanceolatis acuminatis serratis basi rotundatis vix truncatis petiolatis supra glabratis; verticillastris 6-floris; pedicellis calyce subæquilongis; dentibus calycis æqualibus acutis; corolla undique hirsuta, labio superiore longiore. — Mountains above Waimea, Kauai. — Leaves 3 to 4 inches long, 12 to 20 lines wide, long-acuminated. Calyx 4 or 5 lines long, scarcely half as long as the corolla. Most nearly allied to *S. scrophularioides*. (M. & B. 552.)

355. STENOGYNE RUGOSA, Benth. in Bot. Reg. l. c. & in DC. l. c. p. 556; Gray, l. c. (M. & B. 295; Remy, 382.)

356. STENOGYNE ANGUSTIFÓLIA, Gray, l. c. p. 348. (Remy, 393.)

357. STENOGYNE PARVIFLORA (sp. nov.): molliter villoso-pubescens, ramosissima; foliis deltoideis grosse crenatis basi truncatis vel subcordatis (4–6 lin. latis) petiolatis; verticillastris 6–7-floris, pedicellis calyce subæquilongis; calycis (fructiferi ampliati) lobis subinæqualibus latis obtusis tubo multo brevioribus; corolla extus pubescente labio inferiore quam superius longiore calyce plus duplo longiore; staminibus haud exsertis. — On the northwest side of Haleakala, East Maui, at 6000 or 7000 feet elevation. — By its several-flowered whorls, and by the lower lip being longer than the upper, this is most nearly related to the large-leaved group, but resembles *S. diffusa* in its

manner of growth, its small leaves, and general aspect. Spreading, much branched, suffruticose at the base. Leaves 7 – 10 lines long, 4 – 6 lines wide, the crenatures often a line and a half deep; petioles 3 – 4 lines long. Calyx about two lines long, on a pedicel little shorter than itself. Flower 3 or 4 lines long, the lower lip large in proportion, nearly 2 lines long. The sterile specimen referred to by Gray, l. c. p. 348, is from the same locality and belongs here. (M. & B. 407.)

358. STENOGYNE MICROPHYLLA, Benth. Lab. p. 655, & in DC. c. l. p. 556; Gray, l. c. p. 348. (M. & B. 294; Remy, 397.)

359. STENOGYNE CRENATA, Gray, l. c. p. 348. (M. & B. 408.)

360. STENOGYNE DIFFUSA, Gray, l. c. p. 348.

Verbenaceæ.

361.† PRIVA ASPERA, HBK., 2, p. 278; DC. Prodr. 11, p. 534. (M. & B. 74.)

362. VITEX TRIFOLIA, Linn., var.? UNIFOLIOLATA. (M. & B. 409.)

363.† VERBENA BONARIENSIS, Linn., has been introduced and become a very troublesome weed.

363[a].† STACHYTARPHA DICHOTOMA, Vahl. Enum., 1, p. 207. (Remy, 405.)

Myoporineæ.

364. MYOPORUM (POLYCŒLIUM) SANDWICENSE, Gray, in Proceed. Am. Acad. 6, p. 52. *M. tenuifolium*, Hook. & Arn. Bot. Beech. Voy. p. 93, vix Forst. & R. Br. *Polycœlium Sandwicense*, A. DC. Prodr. 11, p. 706. (M. & B. 387; Remy, 462, 463, the normal form.) The normal form of this species is that of a tree 20 to 40 feet high, which is usually found growing on the outskirts of forests at medium elevations, and in rather dry places. With that, it seems necessary to connect a form, in all details of structure apparently similar, but with the leaves much thickened and succulent, as also the petals in a less degree, and growing as a decumbent shrub on the sea-coast, where seeds have doubtless been carried by mountain torrents. (M. & B. 585; Remy, 461.) The wood of this species has very much the fragrance of sandal-wood and is known as *bastard sandal-wood.* It is exported to some extent as sandal-wood, but does not appear to retain its fragrance so well.

Borraginaceæ.

365. CORDIA SUBCORDATA, Lam. Ill. no. 1899; Cham. & Schlecht.

in Linnæa, 4, p. 474. *C. Sebestena*, Forst. Prodr. p. 18, n. 108, non Linn. (M. & B. 350; Remy, 408.)

366. HELIOTROPIUM ANOMALUM, Hook. & Arn. Bot. Beech. Voy. p. 66; Gray, in Proceed. Am. Acad. 5, p. 339; & var. ARGENTEUM, Gray, l. c. *Lithospermum incanum*, Forst. sp. 1, p. 158. *Pentacarya heliotropoides*, DC. Prodr. 9, p. 559. (M. & B. 587; Remy, 411.)

367. HELIOTROPIUM CURASSAVICUM, Linn.; Hook. & Arn. Bot. Beech. Voy. p. 91. (M. & B. 50; Remy, 409.)

368.† BOTHRIOSPERMUM TENELLUM, Fisch. & Mey. (M. & B. 41.)

Hydrophyllaceæ.

369. NAMA SANDWICENSIS, Gray, in Proceed. Am. Acad. 5, p. 338. (M. & B. 97; Remy, 425.)

Convolvulaceæ.

370. BATATAS ACETOSÆFOLIA, Choisy, Conv. Rar. (Remy, 416.)

371.* BATATAS EDULIS, Choisy, Conv. Or. p. 53.

372. BATATAS PENTAPHYLLA, Choisy, l. c. p. 54. (M. & B. 351.)

373. IPOMÆA (CALONYCTION) BONA-NOX, Linn. *Calonyction speciosum*, Choisy, Conv. Or. p. 59. (M. & B.)

374. IPOMÆA (PHARBITIS) INSULARIS, Steud. *Pharbitis insularis*, Chois. Conv. Or. p. 57, & in DC. Prodr. 9, p. 341. *Convolvulus purpureus*, Hook. & Arn. Bot. Beech. Voy. p. 90, non Linn. Remy's No. 414 has the leaves lobed, and more obtuse. (M. & B. 36, 120; Remy, 413, 414, 415.)

375. IPOMÆA PES-CAPRÆ, Sweet. *Convolvulus Pes-capræ*, Linn.; Hook. & Arn. l. c. p. 90. *Ipomæa maritima*, R. Br. Prodr. 486.

376. IPOMÆA TURPETHUM, R. Br. Prodr. 485. (M. & B. 42.)

377. IPOMÆA FORSTERI, Gray, Bot. S. Pacif. Expl. Exp. ined. *I. carnea*, Forst. Prodr. Fl. Ins. Aust. p. 15, non Jacq. *I. obscura*, Guillem. Zeph. Tait. p. 44, vix Rœm. & Schult. *I. sepiaria*, Seem. in Bonpl. 1861, p. 258, vix Kœnig. Var. HAWAIENSIS, Gray, l. c. (W. T. Brigham.)

378. IPOMÆA PALMATA, Forsk. Descr. p. 43. Choisy, in DC. Prodr. 9, p. 386. *Conv. Cairicus*, Linn. According to the description our plant belongs here, as it has silky-tomentose seeds. It otherwise agrees with *I. tuberculata*, Rœm. & Sch., which is said by Gray, l. c. to grow on the Islands, though perhaps by a mistaken determination, as he had no ripe fruit. (M. & B. 345, 227.)

379. Jacquemontia Sandwicensis, Gray, in Proceed. Am. Acad. 5, p. 336. *Convolvulus ovalifolius*, Hook. & Arn. Bot. Beech. Voy. p. 90, non Vahl. *Ipomœa ovalifolia*, var. *pubescens* & var. *tomentosa*, Choisy, Conv. Or. p. 67, & in DC. Prodr. 9, p. 357. (M. & B. 619; Remy, 420.)

380. Bonamia Menziesii, Gray, l. c. p. 336. *Convolvulus ovalifolius* var.? Hook. & Arn. Bot. Beech. Voy. p. 90. (M. & B. 618; Remy, 421.)

381. Cuscuta Sandwichiana, Choisy, Cuscut. p. 184, t. 5, f. 4; Engelm. Cuscut. in Trans. Acad. Sci. St. Louis, 1, p. 497.

Gentianaceæ.

382. Erythræa sabæoides, Gray, in Proceed. Am. Acad. 6, p. 40. *Schenkia sabæoides*, Griseb. in Bonpl. 1, p. 226. (M. & B. 64; Remy, 375.)

Loganiaceæ.

383. Labordea fagræoidea (Gaud.): foliis crasso-coriaceis oblongis seu lanceolato-oblongis acutis supra glabris subtus parce hirsutis breviter petiolatis; cyma sessili pauciflora; pedunculis bibracteatis; lobis calycis ovatis vel ovato-lanceolatis petalis (intus pubescentibus) lineari-lanceolatis flavidis crassis duplo triplove brevioribus; stigmate elongato-clavato pubescente; ovario bi-triloculari; capsulis breviter pedunculatis sublignosis bi-trivalvibus. — *L. fagræoidea*, Gaud. Bot. Freyc. Voy. p. 450, t. 60, non Gray, in Proceed. Am. Acad. 5, p. 323. *L. sessilis*, Gray, l. c. I cannot doubt that this is the original species, as figured and described by Gaudichaud. It differs from the next in the much broader lobes of the calyx and corolla, the fewer-flowered cyme, and the thicker, hirsute leaves. (M. & B. 434.)

384. Labordea pallida (H. Mann.): glabra; foliis obovato-oblongis oblongisve basi in petiolum breviusculum attenuatis penninerviis subcoriaceis, subtus pallidis; cyma sessili pluriflora; calyce (nunc hirsutulo) amplo fere 5-secto, segmentis lanceolatis subfoliaceis nervosis corolla (lobis linearibus) fere dimidio brevioribus; stigmate elongato subclavato; ovario bi-triloculari. — *L. fagræoidea*, Gray, l. c. p. 323, non Gaud. (M. & B. 611.)

385. Labordea hirtella (sp. nov.): foliis coriaceis obovatis oblanceolatisve subito acutis supra glabratis subtus pubescentibus breviter petiolatis; cyma laxe pauciflora cum calyce 5-secto pubescente; lobis calycis subulatis corollæ tubo (fauce ampliato) dimidio brevioribus; cap-

sulis sublignosis bivalvibus. — On the summit of Lanai. — Shrub 5 or 6 feet high, irregularly much branched. Leaves $1\frac{1}{2}$ to $2\frac{1}{2}$ inches long, 9 to 12 lines wide. Flowers on rather long peduncles and pedicels; as in the other species, yellow. Capsule nearly an inch long. (M. & B. 335.)

386. LABORDEA MEMBRANACEA (sp. nov.): foliis amplis ovalibus breviter acuminatis membranaceis subtus pallidis in petiolum basi attenuatis cum ramis novellis inflorescentiaque pilis atro-rufis papilloso-hirsutis; cyma sessili quasi umbellato-contracta; calyce subinflato 5-fido lobis lanceolatis nervosis. — Mountains above Honolulu, Oahu. — A small tree. Leaves 3 to 6 inches long, $1\frac{1}{2}$ to 3 inches wide, thin and membranaceous. (M. & B. 149.)

387. LABORDEA (GENIOSTEMOIDES) TINIFOLIA, Gray, l. c. p. 322. An upright tree 25 or 30 feet high. (M. & B. 562, 610; Remy, 320, 360, 361, 361bis.)

Apocynaceæ.

388. ALYXIA OLIVÆFORMIS, Gaud. Bot. Freyc. Voy. p. 451. *A. sulcata*, Hook. & Arn. Bot. Beech. Voy. p. 90. (M. & B. 99; Remy, 369, 370.)

389. RAUWOLFIA SANDWICENSIS, A. DC. Prodr. 8, p. 339. (M. & B. 113, 336; Remy, 368.)

390. OCHROSIA SANDWICENSIS, A. DC. Prodr. 8, p. 357; Gray, in Proceed. Am. Acad. 5, p. 333. *Cerbera parviflora*, Hook. & Arn. Bot. Beech. Voy. p. 90, non Forst. — There are specimens of an *Ochrosia* with oblong-elliptical obtuse coriaceous leaves, and bearing fruit, in Dr. Wm. Hillebrand's collection; but, wanting flowers, they are too imperfect to be identified with any known species, or to warrant describing as new. (M. & B. 447; Remy, 366, 367.)

391.† VINCA ROSEA, L. (M. & B.)

Oleaceæ.

392. OLEA SANDWICENSIS, Gray, in Proceed. Am. Acad. 5, p. 331. (M. & B. 338; Remy, 479, 482.)

Nyctaginaceæ.

393. PISONIA GRANDIS, Parkinson, ined.; R. Br. Prodr. p. 422. *P. inermis*, Forst. Prodr. n. 397, non Jacq. *P. procera*, Bertero, Deless. Ic. Sel. t. 87. *P. Brunoniana*, Endl. (Remy, 217?)

394. Pisonia excelsa, Blume, Bijdr. p. 735. *P. macrocarpa*, Presl. Symb. t. 56. *P. Forsteriana*, Endl. in Rel. Meyen. t. 51. *P. Sinclarii*, Hook. f. Fl. N. Zeal. 1, t. 50. *P. sylvestris*, Teesm. *P. mitis*, Endl. *P. viscida*, Seem. in Bonpl. *P. umbellifera*, Seem. l. c. & in Journ. Bot. 1, p. 244. (M. & B. 347, 622; Remy, 219.)

395. Bœrhaavia diffusa, Linn. Spec. p. 4. (M. & B. 111.)

Phytolaccaceæ.

396. Phytolacca Bogotensis, HBK. Nov. Gen. & Spec. 2, p. 183; Moq. in DC. Prodr. 13, 2, p. 33. *P. Abyssinica*, Hook. & Arn. Bot. Beech. Voy. 94. *P. brachystachys*, Moq. in DC. l. c. p. 31. (M. & B. 81, 426, 460; Remy, 212.)

Polygonaceæ.

397. Rumex giganteus, Ait. H. Kew. ed. 2, 2, p. 323; Meisn. in A. DC. Prodr. 14, p. 53. — Climbing to the height of forty or fifty feet in the dense forest of Hawaii, and highly ornamental when in fruit, bearing large loose panicles; the calyces turning to a brilliant red. (Remy, 211; M. & B.)

398. Rumex longifolius, DC.? or some allied species, noticed on the Kaala Mountains by the botanists of the Exploring Expedition, (fide Gray, Bot. S. Pacif. Expl. Exp. ined.)

399.† Polygonum glabrum, Willd. (M. & B. 19; Remy, 210.)

Santalaceæ.

400. Santalum Freyienetianum, Gaud. Bot. Freyc. Voy. t. 45; Gray, in Proceed, Am. Acad. 4, p. 326, & in Bot. S. Pacif. Expl. Exp. ined.; A. DC. Prodr. 14, p. 682. Var. Gaudichaudii, Gray, Bot. Expl. Exp. l. c. Var. ellipticum, Gray, Bot. Expl. Exp. l. c. *S. ellipticum*, Gaud. l. c. p. 442; A. DC. Prodr. 14, p. 682; Gray, in Proceed. Amer. Acad. 4, p. 327. Var. latifolium, Gray, in Proceed. l. c. *S. paniculatum*, Hook. & Arn. Bot. Beech. Voy. p. 94. M. & B. 353; Remy, 503, 506, 507, 509.)

401. Santalum pyrularium, Gray, in Bot. Expl. Exp. l. c., & in Proceed. Am. Acad. l. c. p. 327. Vars. *a.* & *β.* Gray, l. c. (Var. *a.* M. & B. 625; Remy, 505. Var. *β.* M. & B. 396.)

402. Exocarpus Gaudichaudii, A. DC. Prodr. 14, p. 90; Gray, Bot. Expl. Exp. l. c. *E. cupressiformis*, Hook. & Arn. Bot. Beech. Voy. p. 95, non R. Br. Var. *β.* foliosa, Gray, l. c. (Var. *a.* M. & B. 299; Remy, 511. Var. *β.* M. & B. 117; Remy, 513, 514.)

Lauraceæ.

403. OREODAPHNE?—We collected specimens of a small tree growing at an elevation of about 2000 feet on the mountains above Waimea, Kauai, in fruit and with very young flower-buds, which may be an *Oreodaphne.* The young branches and inflorescence are silky with a rusty-colored pubescence; the leaves ($2\frac{1}{2}$ to 4 inches long, by 14 to 20 lines wide) are densely reticulate-veiny but not scrobiculate, smooth and shining above and glabrate beneath; the panicles are short, axillary, and few-flowered. (M. & B. 584.)

404. CASSYTHA FILIFORMIS, Linn. (M. & B.)

Thymeleaceæ.

405. WICKSTRŒMIA FŒTIDA, Gray, in Seemann's Jour. Bot. 3, p. 302. Var.? OAHUENSIS, Gray, l. c. (M. & B. 16, 130; Remy, 223.)

406. WICKSTRŒMIA ELONGATA, Gray, l. c. p. 303.

407. WICKSTRŒMIA SANDWICENSIS, Meisn. in DC. Prodr. 14, p. 545; Gray, l. c. 303.

408. WICKSTRŒMIA UVA-URSI, Gray, l. c. (M. & B. 623; Remy, 225.)

409. WICKSTRŒMIA BUXIFOLIA, Gray, l. c. p. 304.

410. WICKSTRŒMIA PHILLYREÆFOLIA, Gray, l. c. p. 304. (M. & B. 304; Remy, 222.)

Chenopodiaceæ.

411. CHENOPODIUM SANDWICHIEUM, Moq. Chenop. Enum. p. 28; & in DC. Prodr. 13, 2, p. 67. (M. & B. 315; Remy, 209.) Var.? MARITIMA: humilius; foliis farinosissimis; paniculis densis. — On the coast, Oahu. (M. & B. 527.)

412. CHENOPODIUM MURALE, Linn.; Moq. in A. DC. l. c. p. 69. (M. & B. 80.)

413. CHENOPODIUM ALBUM, Moq. in A. DC. l. c. p. 70. Var. CANDICANS. *Atriplex Oahuensis,* Meyen, Riese, 2, p. 127.

414. CHENOPODIUM AMBROSIOIDES, Linn.; Moq. in A. DC. l. c. p. 72.

415. BATIS MARITIMA, L.; Torr. in Smithson. Contrib. (M. & B. 118.)

Basellaceæ.

416.* BASELLA RUBRA, L. (M. & B.)

Amaranthaceæ.

417. PTILOTUS (NOTOTRICHIUM) SANDWICENSIS, Gray,* in Bot. S. Pacif. Expl. Exp. ined. (M. & B. 590; Remy, 207.)

418. ACHYRANTHES (ACHYROPSIS) MUTICA, Gray,† in Bot. S. Pacif. Expl. Exp. ined. (Remy, 208.)

419. ACHYRANTHES SPLENDENS, Mart. in A. DC. Prodr. 13, 2, p. 316. (Remy, 206.)

420. ACHYRANTHES BIDENTATA, Blume, Bijdr. p. 545; A. DC. l. c. p. 312. (Remy, 209.)

421. AERVA SERICEA, Moq. in A. DC. Prodr. l. c. p. 305.

422. EUXOLUS LINEATUS, Moq., in A. DC. Prodr. l. c. p. 276.

423. CHARPENTIERA OVATA, Gaud. Bot. Freyc. Voy. p. 444, t. 48; Moq. in A. DC. Prodr. l. c. p. 322. *C. obovata,* Gaud. l. c. t. 47; Moq. l. c. I see no sufficient reason for keeping these two species apart. (M. & B. 79; Remy, 205.)

Urticaceæ.

424. URTICA SANDWICENSIS, Weddell, Monogr. Urtic. p. 67.

425. FLEURYA INTERRUPTA, Gaud.: var. SPICATA, Wedd. l. c. p. 116. *Fleurya spicata,* Gaud. Bot. Freyc. Voy. p. 497.

426. URERA GLABRA, Wedd. l. c. p. 149. *Procris glabra,* Hook. & Arn. Bot. Beech. Voy. p. 96; & var. MOLLIS, Wedd. (M. & B. 398, 400; Remy, 200.)

427. URERA SANDWICENSIS, Wedd. in Ann. Sc. Nat. sér. 3, 18, p. 177, & in Urtic. p. 150. (Remy, 202.)

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* "P. fruticosus, tomentoso-sericeus; foliis oppositis petiolatis ovatis ovalibusque nunc obovatis subtus incanis; spicis ovatis seu cylindraceis pedunculatis vel ad apicem pedunculi ternato-confertis; sepalis ovato-oblongis obtusis dorso cum bracteis rhachique villosissimis, fructiferis conniventibus.

"Var. α: ramis floriferis etiam lignescentibus; foliis ovatis nunc ovato-lanceolatis plerisque acuminatis, rarius ovali-oblongis obtusis basi pl. m. attenuatis.

"Var. β. KAVAIENSIS: ramis fere herbaceis; foliis obovatis obtusissimis basi magis attenuatis subtus tomento subaurato." Gray, Mss.

Hawaii, near the coast; Oahu. Var. β. Coast of Kauai.

† "A. glabella; caule fruticoso ramosissimo; foliis obovatis spathulatis seu fere lanceolatis obtusis viridibus in petiolum gracilem attenuatis; spicis ovatis sessilibus densifloris nunc paucifloris, rhachi subvillosa; bracteis bracteolisque late ovatis mucronulatis flore patente 2-3-plo brevioribus; sepalis 5 ovato-lanceolatis obtusiusculis coriaceo-paleaceis trinerviis; staminibus antheriferis 5; staminodiis oblongis apice laciniatis filamenta adæquantibus."

428. Pilea peploides, Hook. & Arn. l. c. p. 96; Wedd. Urtic. p. 179. *P. pygmæa*, Miq. in Zoll. Syst. Verzeichn. p. 106. *Dubrueilia peploides*, Gaud. l. c. p. 495. (M. & B. 11; Remy, 199.)

429. Bœhmeria stipularis, Wedd. in Ann. Sc. Nat. sér. 4, 1, p. 200, & Urtic. p. 377. *Urtica grandis*, Hook. & Arn. l. c. p. 95. (M. & B. 397; Remy, 195.)

430. Pipturus albidus, Gray, ined. *P. Taitensis*, Wedd. in Ann. Sc. Nat. sér. 4, 1, p. 196, & Urtic. p. 449. *Bœhmeria albida*, Hook. & Arn. l. c. p. 96. Var. Gaudichaudianus, Wedd. Urtic. l. c. *Pipturus Gaudichaudianus*, Wedd. in Ann. Sci. Nat. l. c. — This certainly should retain the specific name of Hooker and Arnott, especially as the name *Taitensis*, given by Weddel, is wholly inappropriate for a plant entirely unknown to Tahiti. (M. & B. 45; Remy, 191.)

431. Neraudia melastomæfolia, Gaud. l. c. p. 500, t. 117; Wedd. Urtic. p. 438, t. 12. *N. ovata*, Gaud. l. c. *Bœhmeria melastomæfolia*, Hook. & Arn. l. c. p. 96. (M. & B. 220.)

432. Neraudia sericea, Gaud. l. c. p. 500, & Bot. Voy. Bonite, t. 133; Wedd. l. c. p. 439. (M. & B. 624.)

433. Touchardia latifolia, Gaud. Bot. Voy. Bonite, t. 94; Wedd. Urtic. p. 142, t. 13. (M. & B. 399.)

434.* Artocarpus incisa, Linn.

435.* Brousonettia papyrifera, Vent.

436. Morus pendulina, Endlich. Prodr. Fl. Norfolk. no. 34. Our plant appears to be the same as the Norfolk Island plant described by Endlicher, and belongs to a section of the genus which, with *Morus Brunoniana*, of Australia, (figured by Endlicher in Atakt. Bot. t. 32, from a drawing by Ferd. Bauer,) has a dry and unchanged calyx in fruit. (Remy, 203, 204.)

Euphorbiaceæ.

437. Euphorbia clusiæfolia, Hook. & Arn. Bot. Beech. Voy. p. 95; Boiss. in A. DC. Prodr. 15-2, p. 11. (M. & B. 627.)

438. Euphorbia (Anisophyllum, Gymnadeniæ) Remyi (Gray, Bot. S. P. Expl. Exp. ined.): "fruticosa, orgyalis, glabra; ramis denudatis ad articulationes nodosis; stipulis in unam interpetiolarem triangularem coalitis; foliis breviuscule petiolatis oblongis vel ellipticis submembranaceis lucidis tenuiter crebre penninerviis integerrimis subacutis vel subacuminatis, basi rotundata fere æquali rarius angustata in-

æquali; cymis axillaribus 1–5-cephalis subsessilibus; pedicellis folio multo brevioribus; involucri campanulati lobis minimis, glandulis transverse ovalibus; capsulæ (aut glabræ aut tomentulosæ) coccis vix carinatis; semine tetragono-obovato scrobiculato-rugoso. — Kauai. Oahu. — Allied to *E. clusiæfolia*, but much taller, inclining to be simple stemmed and arborescent, glabrous, except the slight pubescence on the involucre, and a deciduous tomentum on the capsule. Leaves from 1½ to 5 inches long, and from 10 to 20 lines wide, much thinner than in *E. clusiæfolia*, and the primary veins (from 20 to 30 pairs) more evident, but the ultimate reticulation of veinlets less distinct; the apex never retuse, usually pointed. Petioles 3 to 6 lines long. Pedicels 2 to 3 lines long, sometimes solitary. Lobes of the involucre almost obsolete, emarginate. Styles short; their lobes short and thickish. Capsules small, acutely triangular-3-lobed, and glabrous (immature?), or much larger, 2 lines long, the cocci obtuse on the back. Seed coarsely scrobiculate-rugose." *Gray, mss.* (H. Mann; Remy, 598.)

439. EUPHORBIA MULTIFORMIS, Gaud. Bot. Freyc. Voy. absq. descr.; Hook. & Arn. l. c.; Boiss. in DC. l. c. Var. β. TOMENTELLA (Boiss. l. c.): ramis junioribus et foliis tomentellis. Var. γ. TENUIOR (Gray, l. c. ined.): glabra; ramis gracilibus; foliis ellipticis oblongisve tenuioribus viridioribus. Var. δ. LORIFOLIA (Gray, l. c. ined.): foliis lineari-elongatis (bipollicaribus) crassis; pedicellis involucro 2–4-plo longioribus. Var. ε. CELASTROIDES (Gray, l. c. ined.): glabra; foliis obovato-oblongis spathulatisve basi angusta truncato-subcordata; pedicellis involucro pluries longioribus. — *E. celastroides*, Boiss. in DC. l. c. (M. & B. 101 [γ.], 389 [δ.]; Remy, no. lost.)

440. EUPHORBIA HOOKERI, Steud. Nom. 1, p. 612; Boiss. in DC. l. c. *E. myrtifolia*, Hook. & Arn. l. c. (M. & B. 103.)

441. EUPHORBIA CORDATA, Meyen, Reise, 2, p. 150; Rel. Meyen. p. 412; Boiss. in DC. l. c. p. 13. (M. & B. 106; Remy, 589.)

442.† EUPHORBIA PILULIFERA, Linn. Amœn. Ac. 3, p. 114, non herb.; Boiss. in DC. l. c. p. 21. (M. & B. 35; Remy, 597.)

443.† EUPHORBIA HELISCOPIA, Linn. Spec. p. 658; Boiss. in DC. l. c. p. 136.

444. ANTIDESMA PLATYPHYLLUM (sp. nov.): arborescens; foliis orbiculatis oblongisve obtusis vel acutiusculis chartaceis glabris breviter seu brevissime petiolatis; paniculis ferrugineo-puberulis; bracteis ova-

tis; floribus spicatis; calyce masc. sessili 5- vel plerumque 4-lobo 4–5- (rarissime 6-) andro extus ferrugineo-tomentoso intus glabro; disco lobato glabro; ovarii rudimento obconico hirsuto; stigmate terminali; drupa pedicellata. — Hawaii, Maui, Oahu, Kauai, not uncommon in forests at an elevation of 2,000 or 3,000 feet. — Very closely related to *A. fallax* of Penang, as described by Müller in DC. Prodr. 15–2, p. 253, but differing in the rounder and more obtuse and shorter-petioled leaves, and in the calyx being glabrous within. (M. & B. 427; Remy, 609; Hillebrand, 278bis.)

445. PHYLLANTHUS SANDWICENSIS, Müll. Arg. in Linnæa, 32, p. 31, & in DC. l. c. p. 389. *P. distichus*, Hook. & Arn. Bot. Beech. Voy. p. 95. (M. & B. 104; Remy, 601, 603.)

446.† PHYLLANTHUS NIURI, Linn. (W. T. Brigham.)

447. CLAOXYLON SANDWICENSIS, Müll. Arg. in Linnæa, 34, p. 165, & in DC. l. c. p. 780. (M. & B. 586; Remy, 606.)

448. ALEURITES MOLUCCANA, Willd. Spec. 4, p. 590; Müll. in DC. l. c. p. 723. *A. triloba*, Forst. (M. & B. 51; Remy, 600.)

449.* MANIHOT UTILISSIMA, Pohl. Pl. Bras. 1, p. 32, t. 24, inclus. β & γ, ex Müll. in DC. l. c. p. 1064. (M. & B.)

450.* RICINUS COMMUNIS, Linn. (M. & B.)

Piperaceæ.

451.* PIPER (MACROPIPER) METHYSTICUM, Forst. Prodr. Ins. Aust. n. 21; Hook. & Arn. Bot. Beech. Voy. p. 96. *Macropiper*, Miq. in Comment. Phytogr. p. 36, & Syst. Pip. p. 217.

452. PEPEROMIA PALLIDA, A. Dietr. Spec. 1. p. 153; Miq. l. c. p. 103; Hook. & Arn. l. c. *Piper pallidum*, Forst. l. c. n. 24. — I am not able to give a satisfactory list of species of the Islands, nor can much dependence be placed on these determinations. There are some forms which do not agree with any descriptions which I can find; but rather than add any further confusion by introducing new names, I merely refer to them in this way, especially as the forthcoming volume of the Prodromus will soon exhibit all that is now known concerning them.

453. PEPEROMIA MEMBRANACEA, Hook. & Arn. l. c.; Miq. l. c. p. 120. (Hillebrand, 453, pro parte; M. & B.)

454. PEPEROMIA GAUDICHAUDII, Miq. l. c. p. 137. — This appears scarcely to differ from *P. membranacea*, allowing that (as Miquel's character does not) to have both opposite and whorled leaves.

455. PEPEROMIA SANDWICENSIS, Miq. l. c. p. 126, & Ill. Pip. p. 19, t. 14. (M. & B.)

456. PEPEROMIA INSULARUM, Miq. in Hook. Lond. Journ. Bot. 4, p. 422; Walp. Ann. 3, p. 340.

457. PEPEROMIA LATIFOLIA, Miq. Syst. p. 128, & Ill. Pip. p. 20, t. 15. (M. & B. 243.)

458. PEPEROMIA HYPOLEUCA, Miq. l. c. p. 136, & Ill. Pip. p. 21, t. 17. (Remy, 187, 189; Hillebrand, 453, pro parte.)

459. PEPEROMIA PACHYPHYLLA, Miq. l. c. p. 137. *P. verticillata*, Hook. & Arn. l. c. *Piper verticillatum*, Linn.; Spreng.

460. PEPEROMIA MACRÆANA, Miq. in Seem. Journ. Bot. 4, p. 145.

461. PEPEROMIA LEPTOSTACHYA, Hook. & Arn. l. c.; Miq. Syst. Pip. p. 138.

462. PEPEROMIA REFLEXA, A. Dietr. l. c.; Miq. l. c. p. 169. *Piper reflexum*, Linn. fil. Suppl. p. 91. Forma FORSTERIANA. *Piper tetraphyllum*, Forst. l. c. n. 25. *Peperomia reflexa*, Guill. Zeph. Tait. *P. tetraphylla*, Hook. & Arn. l. c. (M. & B. 242; Remy, 174.)

463. PEPEROMIA ———. A species with narrowly lanceolate, whorled, one-nerved leaves, 9 to 12 lines long, by 2 or 3 lines wide, and small, short-peduncled, axillary and terminal spikes. (Remy, 184.)

Palmeæ.

464. PRITCHARDIA MARTII, Herm. Wendl. in Bonplandia, 10, p. 199. *Livistonia? Martii*, Gaud. Bot. Bonite, t. 58, 59; Mart. Palm. p. 242.

465. PRITCHARDIA GAUDICHAUDII, Herm. Wendl. l. c. *Livistonia? Gaudichaudii*, Mart. l. c. (M. & B. 419.)

466. There is a third Palm with flabellate leaves, growing on inaccessible cliffs, which, I doubt not, is different from either of the preceding.

467.* COCOS NUCIFERA, Linn. Spec. p. 1658.

Pandanaceæ.

468.* PANDANUS VERUS, Rumph. Herb. Amb., ex Kurz, in Seem. Journ. Bot. 5, p. 125. *P. odoratissimus*, Linn. f. Suppl. p. 424.

469. FREYCINETIA ARBOREA, Gaud. Bot. Freyc. Voy. p. 431, t. 41. *F. scandens*, Hook. & Arn. Bot. Beech. Voy. p. 97, non Gaud. — There is only one *Freycinetia* known in the Hawaiian Islands, and this is well figured and described by Gaudichaud, the founder of the

genus, under the name of *F. arborea.* It is, however, never known to grow upright, but climbs over and among trees, making a dense tangle, and is expressively named by the natives i-e – i-e, i-e meaning *to step over.* Possibly Gaudichaud may have been misled by plants growing over the *Dracæna aurea*, and have mistaken the two plants for one, the leaves being somewhat similar; but his specific name, however ill-chosen, could not now well be superseded. Hooker & Arnott, having scandent specimens destitute of flower and fruit, unfortunately referred them to *F. scandens*, Gaud. l. c., of Molucca and Timor, a species with a single small stigma, and in other respects totally different from the Hawaiian one, which has a clavate ovary with a truncate apex bearing 5 to 7 stigmas. This has created a confusion in all subsequent works, which even Kurtz, with Gaudichaud's figures before him, has failed to clear up in his recent monograph of the genus (in Seem. Journ. Bot. 5, p. 133). So far from the species "not existing in nature," it is one of the two species upon which Gaudichaud founded the genus, and differs much from *F. scandens.* (M. & B.)

Aroideæ.

470.* Colocasia antiquorum, var. esculenta, Schott. — The natives distinguish a great number of varieties, some of which yield a much better esculent than others. There is a form which grows high up in mountain valleys, known as *apii*, which has very large leaves and a small and useless corm. The cultivation of the *kalo* is carried on mostly, if not exclusively, by planting the top of the corm (sliced off with the bases of the leaves adhering) usually in artificial ponds: but where there are no surface streams, it is carefully mulched.

Taccaceæ.

471. Tacca pinnatifida, Forster, Gen. Pl. Ins. Aust. t. 35; Seemann, Journ. Bot. 3, p. 261. *T. oceanica*, Nutt. in Amer. Journ. Pharmac. 9, with a plate.

Naiadaceæ.

472. Najas major, All., var. angustifolia, A. Braun, in Seem. Journ. Bot. 2, p. 275.

473. Ruppia maritima, Linn. First detected by Chamisso.

474. Potamogeton Gaudichaudii, Cham. in Linnæa, 2, p. 199.

475. Potamogeton fluitans, var. Owaihiensis, Cham. in Linnæa, 2, p. 228.

476. POTAMOGETON PAUCIFLORUS, Pursh, Fl. 1, p. 121; Cham. l. c. p. 176, t. 4, f. 7. (M. & B. 57.)

Zingiberaceæ.

477. ZINGIBER ZERUMBET, Rosc. in Trans. Linn. Soc. 8, p. 384. (M. & B.)

478.† CANNA INDICA, Linn., has run wild in many places. Also a yellow variety?

Iridaceæ.

479. SISYRINCHIUM ACRE (sp. nov.): glaberrimum; caule simplici ancipiti; foliis radicalibus linearibus 8–10-nerviis scapo brevioribus; spatha communi pedicellis paucis æquilongis vel brevioribus; perigonio flavo, lobis ovatis obtusis 5–7-nerviis; filamentis antheris brevioribus brevissime monadelphis; stigmatibus (stylo longioribus) perigonio brevioribus; capsula obovata. — Common near Kilauea, Hawaii, and on the mountains of that and other of the islands, in dry land. Remarkable for its very short style, and barely monadelphous filaments. The acrid juice of the root is used by the natives for tattooing; applied to the skin it raises blisters, and leaves an indelible blue stain. (M. & B. 438; Remy, 166.)

Dioscoreaceæ.

480.* HELMIA BULBIFERA, Kunth, Enum. Pl. 5, p. 435. *Dioscorea bulbifera*, Linn. (Remy, 162.)

481.* DIOSCOREA PENTAPHYLLA, Linn.

Smilacineæ.

482. SMILAX SANDWICENSIS, Kunth, l. c. p. 253. (M. & B. 222.)

483. SMILAX ANCEPS. Willd. Spec. 4, p. 782. (Remy, 157.)

Commelynaceæ.

484.† COMMELYNA CAYENNENSIS, Rich. *C. agraria*, Kunth. (M. & B. 57.)

485.† TRADESCANTIA FLORIBUNDA, Kunth, Enum. Pl. 4, p. 89. (W. T. Brigham; Hillebrand.)

Orchidaceæ.

486. ANŒCTOCHILUS (MYRMECHIS) SANDWICENSIS, Lindl. Gen. & Sp. Orch. p. 500.

487. ANŒCTOCHILUS JAUBERTII, Gaud. Bot. Bonite, t. 100. — This

belongs to the section of the genus which has the lip fimbriate or dentate on the margin, and can thus be easily distinguished from *A. Sandwicensis*, the lip of which is entire on the margin. (M. & B. 469, 470.)

488. LIPARIS HAWAIENSIS (sp. nov.): foliis binis ovalibus oblongisve obtusis membranaceis plicatis petiolatis scapo angulato dimidio brevioribus; racemo plurifloro; labello obovato integerrimo vel crenato concolore (flavido); sepalis lanceolatis; petalis filiformibus; capsula obovato-clavato costata. — In mountain woods, on trees. — Intermediate between *L. Lœselii* and *L. liliifolia* in general aspect. Leaves $2\frac{1}{2}$ to 4 inches long, by 1 to $2\frac{1}{2}$ inches wide, abruptly contracted into a conspicuous vaginate petiole of an inch or two in length. The labellum is about 3 lines long, and a little shorter than the sepals. The bulb is small. (M. & B. 471.)

Liliaceæ.

489. DRACÆNA AUREA (sp. nov.): arborea, ramosa; foliis coriaceis planis linearibus attenuato-acuminatis; paniculis recurvo-pendulis folioso-bracteatis; pedicellis laxe racemosis solitariis raro geminis; perigonio (sesqui-bipollicari) tubuloso subinfundibuliformi leviter curvato flavo, tubo lobis erectis lineari-oblongis triplo longiore. — Not uncommon throughout the islands. — A tree 20 to 25 feet high. The linear and recurved-spreading leaves $1\frac{1}{2}$ to 2 feet long, an inch or less wide. Panicle a foot long, more or less, the bright lemon-yellow flowers very showy. This differs from the typical species of the genus in the erect lobes as well as the long tube of the perigonium. The berry is red, 4 to 8 lines in diameter, and is much sought after by birds.

490.* CORDYLINE TERMINALIS, Kunth, in Act. Acad. Berol. 1820, p. 30. *Dracæna terminalis*, Reichard; Gaud. Bot. Freyc. Voy. p. 91; Hook. & Arn. Bot. Beech. Voy. p. 97. *Cordyline Eschscholtziana*, Mart. in Schult. Syst. 7. p. 347. (M. & B.)

491. DIANELLA ODORATA, Blume, Enum. 1, p. 13; Hook. & Arn. l. c. p. 218. *D. Sandwicensis*, Hook. & Arn. l. c. p. 97. (M. & B. 89, 364; Remy, 152.)

492. ASTELIA MENZIESIANA, Smith, in Rees, Cycl. App. — Leaves narrowly linear, glabrate above, silky-hairy and chaffy beneath, as is the rest of the plant, excepting the perianth, which is nearly or quite glabrous, its divisions united at the base to form a short tube. (M. & B. 217.)

493. ASTELIA VERATROIDES, Gaud. Bot. Freyc. Voy. p. 420, t. 31. Perhaps only a form of the last; but the leaves are broader, often 3

inches wide, and the whole plant is much more silky, and often densely chaffy. Divisions of the perianth rather broader than in *A. Menziesiana*, and very little if at all united at the base. (M. & B. 392.)

Juncaceæ.

494. Luzula campestris, DC. Fl. Fr. 3, p. 161. (M. & B. 171, 323; Remy, 151.)

495. Joinvillea ascendens, Gaud. Bot. Bonite, t. 39, 40. (M. & B. 330.)

Cyperaceæ.

496. Cyperus trachysanthos, Hook. & Arn. Bot. Beech. Voy. p. 99.

497. Cyperus Prescottianus, Hook. & Arn. l. c. p. 100.

498. Cyperus caricifolius, Hook. & Arn. l. c. p. 99. (M. & B. 54, perhaps referable here.)

499. Cyperus multiceps, Hook. & Arn. l. c. p. 100.

500. Cyperus mucronatus, Rottb. Gram. 19, t. 8, f. 4; Hook. & Arn. l. c. p. 99. (M. & B. 43; Remy, 120.)

501. Cyperus brunneus, Sw. Fl. Ind. Occ. 1, p. 116; Hook. & Arn. l. c. p. 99. (M. & B. 14; Remy, 115.)

502. Cyperus polystachyus, Rottb. Gram. 39, t. 11, f. 1. (M. & B. 70; Remy, 114.)

503. Cyperus pennatus, Lam. Ill. 1, p. 114. *C. canescens*, Vahl. Enum. 2, p. 355. *Mariscus albescens*, Gaud. Bot. Freyc. Voy. p. 415. (M. & B.; Remy, 118.)

504. Cyperus viscosus, Ait. Kew, 1, p. 79; Jacq. Ic. 2, t. 295.

505. Cyperus cæspitosus, Poir. Dict. 7, p. 250?; Hook. & Arn. l. c. p. 99.

506. Cyperus paniculatus, Rottb.? Hook. & Arn. l. c.

507. Cyperus strigosus, Linn.; Hook. & Arn. l. c.

508. Cyperus auriculatus, Nees & Meyen, in Linnæa, 9, p. 285.

509. Cyperus (Mariscus) Kunthianus. *M. Kunthianus*, Gaud. Bot. Freyc. Voy. p. 415; (M. & B. 324.)

510. Cyperus (Mariscus) phleoides. *M. phleoides*, Nees, ex Steud. Glum. p. 62.

511. Cyperus (Mariscus) Hawaiensis (sp. nov.): culmo triquetro lævi basi folioso; foliis linearibus margine scabris culmum adæquantibus; involucro 6–8-phyllo, foliolis 2 elongatis; spicis ovalibus pluribus subsessilibus arcte congestis vel breviter pedunculatis; squamis inferi-

oribus minimis, mediis triplo majoribus 9-nerviis lævibus, interioribus brevioribus uninerviis. — On the mountains of Hawaii, Maui, and Kauai. — Somewhat resembling *M. phleoides*, but smaller, and the spikes shorter. (M. & B. 246.)

512.† KYLLINGIA MONOCEPHALA, Rottb. Gram. p. 13, t. 4. (M. & B. 23; Remy, 123.)

513. ELEOCHARIS OBTUSA, Schult. Mant. 2, p. 89; Gaud. Bot. Freyc. Voy. p. 414; Hook. & Arn. l. c. (M. & B. 27; Remy, 128.)

514. ELEOCHARIS PALUSTRIS, R. Brown. Prodr. p. 244.

515. SCIRPUS MARITIMUS, Linn.; Hook. & Arn. l. c. p. 98. (M. & B. 69, 230; Remy, 129.)

516. SCIRPUS RIPARIUS, Presl, Rel. Hænk. 1, p. 192. (M. & B. 25.)

517. FIMBRISTYLIS CYMOSA, R. Br. Prodr. p. 228; Hook. & Arn. l. c. p. 98. (M. & B. 22.)

518. FIMBRISTYLIS UMBELLATO-CAPITATA, Steud.? A very variable plant, from Waterlandt Island, Tutuilla, etc., as well as the Hawaiian Islands. The spikes are always sessile in a head, but the heads are solitary, or few, or numerous, subtended by 3–5 very short (or with one or two longer) awl-shaped bracts. The squamæ are ovate, acutish, concave, and somewhat keeled; the styles trifid and the stamens two; the achenia are less convex on one side than the other, three-angled and very obtuse at the apex. Probably not the species quoted, from which it differs in several particulars, but I am unable to identify it satisfactorily, though it must be well known.

519. RHYNCHOSPORA LAVARUM, Gaud. Bot. Freyc. Voy. p. 415; Hook. & Arn. l. c. p. 98. (M. & B. 219; Remy, 134.)

520. RHYNCHOSPORA THYRSOIDEA, Nees & Meyen, 9, p. 297. *R. scleroides*, Hook. & Arn. l. c. p. 99. (M. & B. 90; Remy, 132.)

521. CLADIUM LEPTOSTACHYUM, Nees & Meyen, in Linnæa, 9, p. 301, & Rel. Meyen. p. 115. (M. & B. 112.)

522. BAUMEA MEYENII, Kunth, Enum. p. 314. *Vincentia angustifolia*, Hook. & Arn. l. c. p. 98. (M. & B. 92; Remy, 138.)

523. VINCENTIA ANGUSTIFOLIA, Gaud. Bot. Freyc. Voy. p. 417, non Hook. & Arn. l. c.

524. GAHNIA GAUDICHAUDII, Steud. Glum. p. 164. *Lamprocarya Gaudichaudii*, Brongn. in Bot. Dup. Voy. p. 166. *Morelotia gahniæformis*, Gaud. Bot. Freyc. Voy. p. 416, t. 28. — Dr. Hooker, in Fl. N. Zeal., while, through some oversight, he refers *M. gahniæformis* to *L. affinis*, Brongn. (*Gahnia arenaria*, Hook. l. c.), speaks of the Hawaiian

plant as a different but closely allied species; as it is. The character upon which Brown distinguished the genus *Lamprocarya* from *Gahnia* (that of not having a transversely grooved nut) only throws the most closely allied species into different genera.

525. GAHNIA BEECHEYI (sp. nov.): glaberrima; culmo tereti lævi; foliis linearibus longissimis superne filiformibus reclinatis arcte convolutis margine scabris dorso aculeis parvis asperatis; panicula (10-12-pollicari) spicis axillaribus (sesqui-bipollicaribus) multifloris; bracteis ut foliis; bracteolis ovato-lanceolatis mucronatis, carina ciliata; spiculis unifloris; squamis ovato-lanceolatis acutis, intimis obtusiusculis; nuce oblonga obscure trigona flava nitida styli basi cuspidata intus transverse sulcata. — On mountain ridges at 1,000 to 3,000 feet elevation. — Apparently most nearly allied to *G. schœnoides* of Tahiti. (M. & B. 91; Remy, 136; Macrae.)

526. GAHNIA GLOBOSA (sp. nov.): glaberrima; culmo tereti lævi; foliis linearibus elongatis culmum superantibus convolutis subtus læviusculis, margine nervis supraque scabris; spicis globosis axillaribus e spiculis (18-25) unifloris arcte congestis compositis; bracteis e basi lata lanceolatis acuminatissimis; bracteolis ovato-lanceolatis acuminatis; squamis late ovatis orbiculatisve acuminatis, intimis obtusis; nuce ovata flava extus longitudinaliter rugosa styli basi cuspidata intus haud sulcata. — With the preceding. — At once distinguished by the dense globose spikes in a short interrupted panicle, and the broadly ovate squamæ. Apparently often gathered by collectors, but by Hooker & Arnott confounded with *Morelotia Gahniæformis*, Gaud., and by others with *Lamprocarya affinis*, Brongn., &c. Probably identical with a poor specimen of Seemann's, no. 672, from the Viti Islands, which he has called *L. affinis*, Brongn. (W. T. Brigham.)

527. OREOBOLUS FURCATUS (sp. nov.): dense pulvinato-cæspitosus, ramosus, foliosus; foliis basi vaginantibus nervosis dense imbricatis lineari-subulatis acutis obtusiusculisve rigidis serrulatis; scapo sulcato terminali simplici vel furcato 1-4-floro; bracteis foliosis; bracteolis scariosis; perianthii foliolis ciliatis integerrimis. — On the summits of the mountains of Maui and Kauai. — Most nearly allied to *O. obtusangulus*, Gaud., from which it differs in its often several-flowered scape, in the leaves being serrulate, etc. (M. & B. 436; U. S. Expl. Exped.)

528. SCLERIA TESTACEA, Nees, l. c. 9, p. 303. (M. & B. 329.)

529. CAREX COMMERSONIANA, Sieb. ex Kunth, Enum. p. 291. (M. & B. 260, 391.)

530. CAREX MEYENII, Nees, in Rel. Meyen. p. 123; Steud. Glum. p. 195. (Remy, 141, fide Boott.)

531. CAREX WAHUENSIS, C. A. Meyer, Cyp. Nov. in Mem. Acad. St. Petersb. 1, p. 218, t. 10; Boott, Ill. Gen. Carex, 3, p. 111, t. 351-354. (M. & B. 328, 331; Remy, 145.)

532. CAREX NUPTIALIS, Boott, in herb. Gray. (Remy, 142.)

533. CAREX PRESCOTTIANA, Boott, in Linn. Trans. 20, p. 135, & Ill. Gen. Carex, 1, p. 45, t. 115. (M. & B. 325; Remy, 148.)

534. CAREX FESTIVA, Dewey, in Am. Journ. Sc. 29. (M. & B. 332; Remy, 146.)

535. UNCINIA LINDLEYANA, Kunth, Enum. 2, p. 526. (M. & B. 437; Remy, 140.)

Gramineæ.

The Grasses being all in the hands of Colonel Munro, I cannot at present give a list of them. They show considerable novelty, and a large proportion are peculiar to the Group. There are about fifty species.

*Filices.**

536. GLEICHENIA GLAUCA, Hook. Sp. Fil. 1, p. 4. *Mertensia glauca*, Sw. Syn. Fil. p. 164 & 390 (non *Gleichenia glauca*, Sw.); Brack. Fil. S. Pacif. Expl. Exped. p. 292. (M. & B. 496.)

537. GLEICHENIA GLABRA, Brack. l. c. p. 292, sub *Mertensia*.

538. GLEICHENIA OWHYHENSIS, Hook. l. c. 1, p. 9. *Mertensia Hawaiensis*, (a much better name,) Brack. l. c. p. 295. (M. & B. 472.)

539. GLEICHENIA DICHOTOMA, Hook. l. c. 1, p. 12. *Mertensia dichotoma*, Willd. Spec.; Gaud. Bot. Freyc. Voy. p. 301; Brack. l. c. p. 297. (M. & B. 145.)

540. GLEICHENIA EMARGINATA, Brack. l. c. p. 297, t. 42. (M. & B. 495.)

541. CIBOTIUM GLAUCUM, Hook. & Arn. Bot. Beech. Voy. p. 108, (excl. syn. Kaulf. & Gaud.); Hook. l. c. 1, p. 82, t. 29, A; Brack. l. c. p. 279. (M. & B. 543; Remy, 48.)

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* I have to thank Prof. D. C. Eaton, of New Haven, for most kindly rendering assistance and advice concerning all difficult points in this order. For the determinations and synonymy as here adopted, however, I am alone responsible.

542. Cibotium Chamissoi, Kaulf. Enum. Fil. p. 230, t. 1, f. 14; Hook. l. c. 1, p. 83; Brack. l. c. p. 279. *Pinonia splendens*, Gaud. Bot. Freyc. Voy. p. 369, t. 21. (M. & B. 141.)

543. Cibotium Menziesii, Hook. l. c. 1, p. 84, t. 29, C.; Brack. l. c. p. 280. (M. & B. 511; Remy, 50.)

544. Deparia prolifera, Hook. & Arn. l. c. p. 108; Hook. Gen. Fil. t. 44, B; Hook. Spec. l. c. 1, p. 84; Brack. l. c. p. 240. *D. Macræi*, Hook. & Grev. Ic. Fil. t. 154. *Dicksonia prolifera*, Kaulf. Enum. Fil. p. 225. *Cibotium proliferum*, Presl, Tent. Pterid. p. 69, t. 11, f. 10. (M. & B. 151.)

545. Odontoloma Macræana, Brack. l. c. p. 226. *Davallia Macræana*, Hook. & Arn. l. c. Referred by Hook. in Spec. Fil. 1, p. 175 to *D.* (*O.*) *Boryana*, Presl, but it appears to be sufficiently distinct. (M. & B. 148.)

546. Microlepia tenuifolia, Metten. *Davallia tenuifolia*, Sw. Syn. Fil. p. 133, 350; Hook. l. c. 1, p. 186; Brack. l. c. p. 248. *D. remota*, Kaulf. Enum. Fil. p. 223; Hook. & Arn. l. c. p. 108. (M. & B. 143; Remy, 47.)

547. Microlepia hirta, Presl, Tent. Pterid. p. 125; Brack. l. c. p. 239. *Dav. hirta*, Kaulf. l. c. p. 223; Hook. & Arn. l. c. p. 108; Hook. l. c. 1, p. 181. *Dicksonia Kaulfussiana*, Gaud. Bot. Freyc. Voy. p. 368?; Hook. l. c. 1, p. 71? (M. & B. 144; Remy, 44, 46.)

547^a. Microlepia polypodioides, Presl, l. c. *Dav. polypodioides*, Don; Hook. l. c. 1, p. 181. Recorded by Hooker as a native of the Islands, and mentioned by Brackenridge under *D. hirta*, but I have seen nothing like it.

548. Microlepia Mannii, Eaton (sp. nov.): "caudice repente; stipitibus basi fere nudis exarticulatis spithamæis crassitie pennæ corvinæ teretibus rhachique atris nitidis; fronde bipedali anguste lanceolata bipinnata; pinnis triangulari-lanceolatis 2–3-uncialibus costa tenui nigrescente instructis; pinnulis bipinnatifidis; segmentis ultimis opaco-viridibus lineari-spathulatis augustissimis venulis singulis donatis, fertilibus apice dilatatis sorumque transverse-oblongum ferentibus simplicibus vel sæpe ramum brevem e latere exteriori infra sorum emittentibus; involucris pallidis basi lata vel semicirculari adnatis. — Mountains of Waimea, Kauai, 2,000 to 3,000 feet above the sea. — This Fern is to be placed in the same group with *M. gibberosa* (*Davallia gibberosa*, Sw.), with which species it agrees pretty well in the position and form of the sori and involucres, though the black and shining

stipe and rhachis and the very narrow segments (about $\frac{1}{4}$ of a line wide) make it at once a very distinct and extremely elegant species." *Eaton, mss.* (M. & B. 546.)

549. CYSTOPTERIS DOUGLASII, Hook. l. c. 1, p. 200; Brack. l. c. p. 232. *C. Sandwicensis*, Brack. l. c. p. 234. (M. & B. 480.)

550. ADIANTUM CAPILLUS-VENERIS, Linn.; Hook. l. c. 2, p. 36; Gaud. Bot. Freyc. Voy. p. 404; Brack. l. c. p. 96. (M. & B. 138.)

551. PELLÆA TERNIFOLIA, Fee, Gen. Fil. p. 129; Hook. l. c. 2, p. 142. *Platyloma ternifolia*, Brack. l. c. p. 94. (M. & B. 262.)

552. PTERIS CRETICA, Linn.; Hook. l. c. 2, p. 159; Brack. l. c. p. 113. (M. & B. 252; Remy, 34.)

553. PTERIS IRREGULARIS, Kaulf. Enum. Fil. p. 189; Hook. l. c. 2, p. 173; Brack. l. c. p. 116. *P. alata*, Gaud. Bot. Freyc. Voy. p. 391, t. 19; Hook. & Arn. l. c. p. 107. (M. & B. 162; Remy, 35, 36.)

554. PTERIS EXCELSA, Gaud. Bot. Freyc. Voy. p. 388; Hook. l. c. 2, p. 183, t. 136; Brack. l. c. p. 115. (M. & B. 163.)

555. PTERIS AQUILINA, Linn.; Hook. l. c. 2, p. 196; Brack. l. c. p 119. *P. decomposita*, Gaud. Bot. Freyc. Voy. p. 393. (M. &. B. 484.)

556. PTERIS (LITOBROCHIA) DECIPIENS, Hook. l. c. 2, p. 209. *Pt. pedata*, Hook. & Arn. l. c. p. 107; Gaud. Bot. Freyc. Voy. p. 384. *Doryopteris pedata*, Brack. l. c. p. 103 "as far only as the specimens from the Sandwich Islands are concerned." Hook. l. c. (M. & B. 136.) *

557. PTERIS (LITOBROCHIA) DECORA, Hook. l. c. 2, p. 210. *Doryopteris decora*, Brack. l. c. p. 103. (M. & B. 253.)

558. SADLERIA CYATHEOIDES, Kaulf. Enum. Fil. p. 162; Hook. & Arn. l. c. p. 107. *Blechnum Fontanesianum*, Gaud. Bot. Freyc. Voy. p. 397, t. 15; Brack. l. c. p. 133. *Bl. Kaulfussianum*, Gaud. Bot. Bonite, t. 78. (M. & B. 155; Remy, 33.)

559. SADLERIA PALLIDA, Hook. & Arn. l. c. pp. 75 & 107. *Bl. pallidum*, Brack. l. c. p. 133. *Bl. Souleytianum*, Gaud. Bot. Bonite, t. 134. (M. & B. 188; Remy, 32.)

560. SADLERIA SQUARROSA. *Bl. squarrosum*, Gaud. Bot. Bonite, t. 2, f. 1–6. *Bl. polystichoides*, Brack. l. c. p. 134.—These Ferns

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* *Pellœa geraniæfolia*, Fee, is recorded by Hooker, l. c. 2, p. 133, as a native of the Hawaiian Islands; but I presume he intends to correct that when he says on p. 209, "This I had at one time believed to be identical with *P. geraniæfolia*," &c. I have never seen, nor do I know of *P. geraniæfolia* occurring at the Hawaiian Islands.

appear to be sufficiently distinct. The first two species are decidedly arborescent, the trunk of *S. pallida* being often 6 feet high, while the whole plant is often 12 or 15 feet high, and of a much more erect manner of growth than *S. cyatheoides*. *S. squarrosa*, on the contrary, is diminutive in comparison with the two others, usually having but a very small trunk-like caudex, or none at all. I have seen specimens not over a foot high, including caudex and all, in luxuriant fructification.

561. Doodia Kunthiana, Gaud. Bot. Freyc. Voy. p. 401, t. 14; Hook. & Arn. l. c. p. 107; Brack. l. c. p. 137. (M. & B. 165; Remy, 30.)

562. Lindsæa (Diellia) erecta, Brack. l. c. p. 218, t. 31, sub *Diellia*. (M. & B. 483.)

563. Lindsæa (Diellia) falcata, Brack. l. c. p. 219, t. 31, sub *Diellia*.

564. Lindsæa (Diellia) pumila, Brack. l. c. sub *Diellia*.

565. Asplenium (Thamnopteris) Nidus, Linn.; Hook. l. c. 3, p. 77. *Neottopteris Nidus*, Brack. l. c. p. 175. (M. & B. 137.)

566. Asplenium obtusatum, Forst. Prodr. Ins. Aust. p. 80; Hook. l. c. 3, p. 96. Var. obliquum, Hook f. Fl. Ant. p. 108, Fl. N. Zeal. 2, p. 33. *A. obliquum*, Forst. l. c.; Hook. & Arn. l. c. p. 106; Brack. l. c. p. 154. (M. & B. 169.)

566[a]. Asplenium lucidum, Forst. l. c. p. 80; Hook. l. c. 3, p. 98. — It is not improbable that a form of the last species (if the two are really distinct) has been taken for this, in referring it to the Hawaiian Islands. Menzies is, so far as I know, the only authority for this habitat.

567. Asplenium gemmiferum, Schrad. Gott. Gel. Anz. 1818, p. 916; Hook. l. c. 3, p. 99. *Darea flaccida*, β. Hook. & Arn. l. c. p. 107.

568. Asplenium enatum, Brack. l. c. p. 153, t. 21; Hook. l. c. 3, p. 106. (M. & B. 485.)

569. Asplenium Kaulfussii, H. Mann, non Schrad. *A. protensum*, Kaulf. Enum. Fil. p. 167, a. 1826 (non Schrad. a. 1818, in Gott. Gel. Anz. p. 916); Hook. l. c. 3, p. 106, adnot.; Brack. l. c. p. 153. Perhaps this is what Hooker refers to under *A. falcatum* when he credits it as "very small, whole plant not 4 inches high," to the Hawaiian Islands. — It is with some hesitation that I have altered this name, but the *protensum* of Schrader has six years the precedence of that of Kaulfuss. The species under consideration appears to be

known to very few botanists, and to be thought of somewhat doubtful existence by Hooker, l. c. p. 106. (M. & B. 571.)

570. ASPLENIUM ERECTUM, Bory; Hook. l. c. 3, p. 126, which see for synonymy. Var. PROLIFERUM, Hook. Fil. Exot. t. 72. *A. pavonicum*, Brack. l. c. p. 150. (M. & B. 186; Remy, 23.) Var. SUBPINNATIFIDUM, Hook. (M. & B. 173 pro parte, 490.)

571. ASPLENIUM RESECTUM, Smith, Ic. Ined. t. 72; Hook. & Grev. Ic. Fil. t. 114; Hook. & Arn. l. c. p. 106; Brack. l. c. p. 149; Hook. l. c. 3, p. 130. (M. & B. 168; Remy, 25.)

572. ASPLENIUM TRICHOMANES, Linn.; Hook. l. c. p. 136. *A. densum*, Brack. l. c. p. 151, t. 20. (M. & B. 257; Remy, 22.)

573. ASPLENIUM MONANTHEMUM, Linn.; Brack. l. c. p. 151, t. 20, f. 2; Hook. l. c. 3, p. 140. *A. Menziesii*, Hook. & Grev. Ic. Fil. t. 100; Brack. l. c. p. 151. (M. & B.)

574. ASPLENIUM FRAGILE, Presl, Tent. Pterid. p. 108; Hook. Ic. Pl. t. 932; Hook. l. c. 3, p. 144. *A. rhomboideum*, Brack. l. c. p. 156, t. 21, f. 2.

575. ASPLENIUM CAUDATUM, Forst. Prodr. Ins. Aust. p. 80; Hook. l. c. 3, p. 152.

576. ASPLENIUM HORRIDUM, Kaulf. Enum. Fil. p. 175; Hook. & Arn. l. c. p. 106; Brack. l. c. p. 158; Hook. l. c. 3, p. 153, t. 193. (M. & B. 158.)

577. ASPLENIUM CONTIGUUM, Kaulf. Enum. Fil. p. 175; Hook. & Arn. l. c. p. 106; Brack. l. c. p. 158; Hook. l. c. 3, p. 156, t. 194. *A. filiforme*, Kaulf. l. c.; Hook. & Arn. l. c.; Brack. l. c. In a specimen in our collection some fronds bear pinnæ but 7 lines long by 6 lines wide, while others from the same root have pinnæ 2½ inches long and but 5 lines wide. (M. & B. 156, 160, 280.)

578. ASPLENIUM FALCATUM, Lam.? A Fern, probably distinct from *A. falcatum*, which I have not been able to identify satisfactorily. (M. & B. 514.)

579. ASPLENIUM FURCATUM, Thunb. Prodr. Fl. Cap. p. 172; Brack. l. c. p. 162; Hook. l. c. 3, p. 165. (M. & B. 261; Remy, 27.)

580. ASPLENIUM NITIDUM, Sw. Syn. Fil. pp. 84, 280; Hook. l. c. p. 172; *A. cristatum*, Brack. l. c. p. 163, t. 21, f. 3? (non Wall.) *A. insiticum*, Brack. pro parte. (M. & B. 167, 191, 515.)

581. ASPLENIUM SPATHULINUM, J. Sm. in Hook. Journ. Bot. 3, p. 408; Hook. l. c. 3, p. 170. *A. insiticum*, Brack. pro parte. (M. & B. 264, 477; Remy, 31.)

582. Asplenium acuminatum, Hook. & Arn. l. c. p. 106; Brack. l. c. p. 164; Hook. l. c. 3, p. 183, t. 206. (M. & B. 494.)

583. Asplenium Adiantum-nigrum, Linn.; Hook. l. c. 3, p. 187. Var. Gaudichaudianum, Hook. l. c. 3, p. 188. *A. Adiantum-nigrum*, Brack. l. c. p. 320. *A. patens*, Gaud. Bot. Freyc. Voy. p. 320. (M. & B. 259; Remy, 36.)

584. Asplenium dissectum, Brack. l. c. p. 170, t. 24; Hook. l. c. 3, p. 189. (M. & B. 478, 572.)

585. Asplenium Macræi, Hook. & Grev. Ic. Fil. t. 217; Brack. l. c. p. 159. (M. & B. 173 pro parte, 549; Remy, 24.)

586. Asplenium strictum, Brack. l. c. p. 168, t. 23, f. 1; Hook. l. c. 3, p. 200. *A. patens*, Hook. & Arn. l. c. p. 106 (non p. 274).

587. Asplenium deparioides, Brack. l. c. p. 172.

588. Asplenium Porietianum, Gaud. Bot. Freyc. Voy. p. 327, t. 13; Brack. l. c. p. 175. (M. & B. 265.)

589. Asplenium multisectum, Brack. l. c. p. 174. (M. & B.)

590. Asplenium Sanwichianum, Metten. Asplen. p. 197. *Athyrium*, Presl, Epim. Bot.

591. Aplenium arborescens, Metten. Fil. Hort. Lips, p. 78. Perhaps the *Aspl. diplazioides*, Hook. & Arn. l. c. p. 107, will claim rank as a good species after all, as there is a Diplazioid Fern which is by no means aborescent.

592. Asplenium polypodioides, Metten, l. c. — I quote this name and the last, to represent what are probably two species of Diplazioid Ferns from the Islands, but I am not satisfied that the determinations are correct. They are numbered 166 & 172 in our collection.

593. Aspidium aculeatum, Sw.; Hook. l. c. 4, p. 18. Var. This seems never to have been collected on the Hawaiian Islands before. We found it on the Western base of Mauna Loa, in woods in Kona, Hawaii, at an elevation of 5,000 or 6,000 feet. (M. & B. 258.)

594. Aspidium Haleakalense, Brack. l. c. p. 204, t. 28 (sub *Polysticho*). I cannot at all agree with Hooker in referring this very well marked Fern to *A. aculeatum*. (M. & B. 481.)

595. Aspidium (Cyrtomium) carytoideum, Wall. Cat. n. 376; Hook. & Grev. Ic. Fil. t. 69; Hook. l. c. 4, p. 41; Brack. l. c. p. 184. (M. & B. 487.)

596. Aspidium (Sagenia) cicutarium, Sw. in Schrad. Journ. 1803, 2, p. 279; Hook. l. c. 4, p. 49. *Aspid. apiifolium*, Schk. Fil. p. 128, t. 36, B.?; Brack. l. c. p. 182. *Nephrodium apiifolium*, Hook.

& Arn. l. c. p. 313! *Aspidium sinuatum*, Gaud. Bot. Freyc. Voy. p. 343. I have specimens from 6 inches long, and nowhere truly pinnate, to others 2 or 3 feet long, and tripinnatifid or tripinnate, the segments varying much in shape. (M. & B. 184.)

597. Aspidium Hudsonianum. *Nephrodium*, Brack. l. c. p. 189, t. 25. This is referred by Hooker, l. c. 4, p. 72, to *A. extensum*, Blume. (M. & B. 153.)

598. Aspidium cyatheoides. *Nephrodium*, Kaulf. Enum. Fil. p. 234; Brack. l. c. p. 189; Hook. l. c. 4, p. 76, t. 241, A. *Polystichum Dubreuillianum*, Gaud. Bot. Freyc. Voy. p. 333, t. 9. (M. & B. 152; Remy, 13.)

599. Aspidium unitum, β hirsutum, Metten. in Ann. Mus. Lugd.-Bat. 1, p. 230. *A. resiniferum*, Kaulf. *Nephr. resiniferum*, Hook. & Arn. l. c. p. 105; Brack. l. c. p. 185. *Polyst. propinquum*, Gaud. Bot. Freyc. Voy. p. 330. — It is in vain that I have tried to unravel the rest of the synonymy of this species; it however appears to be both the *N. propinquum* & *unitum* of R. Br. Prodr. p. 148, and not *N. unitum*, Sieber, in Hook. l. c. 4, p. 81. (M. & B. 269; Remy, 20, 21.)

600. Aspidium patens, Sw. Syn. Fil. p. 49. *Nephrodium*, Hook. l. c. 4, p. 95.

601. Aspidium globuliferum. *Lastrea globulifera*, Brack. l. c. p. 194. *Nephrodium*, Hook. l. c. 4, p. 96.

602. Aspidium Filix-mas, Sw. l. c. p. 55. *Nephrodium*, Rich.; Hook. l. c. 4, p. 116. *Lastrea truncata*, Brack. l. c. p. 195, t. 27. Var. paleaceum. (M. & B. 255.)

603. Aspidium latifrons, Brack. l. c. p. 196. *Nephrodium*, Hook. l. c. 4, p. 138. (M. & B. 189, 195, 196.)

604. Aspidium rubiginosum. *Lastrea*, Brack. l. c. p. 201. *Nephrodium*, Hook. l. c. 4, p. 143. *N. Fijiense*, Hook. 2d Century of Ferns, t. 67.

605. Aspidium squamigerum. *Nephrodium*, Hook. & Arn. l. c. p. 106; Hook. l. c. 4, p. 144. *Lastrea squamigera*, Brack. l. c. p. 198. (M. & B. 505.)

606. Aspidium glabrum, Metten. *Lastrea glabra*, Brack. l. c. p. 200. (M. & B. 266, 185 pro parte.)

607. Aspidium ——————? An undetermined species. (M. & B.)

608. Nephrolepis exaltata, Schott; Hook. l. c. 4, p. 152; Brack. l. c. p. 211. *Nephrodium exaltatum*, Gaud. Bot. Freyc. Voy. p. 336. (M. & B. 142; Remy, 43.)

609. PHEGOPTERIS HONOLULENSIS. *Polypodium*, Hook. l. c. 4, p. 254 (sub nom. *Hillebrandi;* vide Hook. l. c. p. 288, adnot.)

610. PHEGOPTERIS CRINALIS. *Polypodium*, Hook. & Arn. l. c. p. 105; Brack. l. c. p. 15; Hook. l. c. 4, p. 266. (M. & B. 502.)

611. PHEGOPTERIS UNIDENTATA. *Polypodium*, Hook. & Arn. l. c. p. 105; Brack. l. c. p. 17; Hook. l. c. 4, p. 267. (M. & B. 185 pro parte, 501, 592.)

612. PHEGOPTERIS SANDWICENSIS. *Polypodium*, Hook. & Arn. l. c. p. 105; Brack. l. c. p. 17; Hook. l. c. 4, p. 267. (M. & B. 591.)

613. PHEGOPTERIS KERAUDRENIANA. *Polypodium*, Gaud. Bot. Freyc. Voy. p. 362, t. 7; Brack. l. c. p. 15; Hook. l. c. 4, p. 268. Var. β Hook. l. c. (M. & B. 278.)

614. PHEGOPTERIS PROCERA. *Polypodium*, Brack. l. c. p. 14, t. 3; Hook. l. c. 4, p. 269.—Hooker's var. β of the last species is so entirely intermediate between the simplest form of *P. Keraudreniana* and the present Fern, as to render it altogether probable that they pass into one another, as he supposes. (M. & B. 508.)

615. PHEGOPTERIS MICRODENDRON, Eaton, mss. *Polypodium Sandwicensis*, Hook. l. c. 5, p. 5 (non Hook. l. c. 4, p. 267.) *Stegnogramma Sandwicense*, Brack. l. c. p. 26. (M. & B. 476.)

616. POLYPODIUM PSEUDO-GRAMMITIS, Gaud. Bot. Freyc. Voy. 4, 345; Hook. & Arn. l. c. p. 103, t. 21, B; Brack. l. c. p. 3; Hook. l. c. 4, p. 165. (M. & B. 180.)

617. POLYPODIUM HOOKERI, Brack. l. c. p. 4; Hook. l. c. 4, p. 171. *P. setigerum*, Hook. & Arn. l. c. p, 103, t. 21, A., non Blume? (M. & B. 482.)

618. POLYPODIUM SERRULATUM, Metten. Polypod. p. 32?; Hook. l. c. 4, p. 174? *P. minimum*, Brack. l. c. p. 5, t. 1. *Xiphopteris Jamesoni*, Hook. 2d Cent. of Ferns, t. 14?—The Hawaiian Fern has a different appearance from the West Indian and South American one. (M. & B. 550.)

619. POLYPODIUM SUBPINNATIFIDUM, Blume, Enum.; Hook. l. c. 4, p. 177. *P. Haalilioanum*, Brack. l. c. p. 5. (M. & B. 178.)

620. POLYPODIUM ADENOPHORUS, Hook. & Arn. l. c. p. 104, t. 22; Brack. l. c. p. 8; Hook. l. c. 4, p. 195. *P. pendulum*, Gaud. Bot. Freyc. Voy. p. 349 (non Sw.). *Adenophorus pinnatifidus*, Gaud. l. c. p. 365. (M. & B. 283.)

621. POLYPODIUM SARMENTOSUM, Brack. l. c. p. 8, t. 2, f. 3; Hook. l. c. p. 195. (M. & B. 200.)

622. Polypodium pellucidum, Kaulf. Enum. Fil. p. 101; Gaud. Bot. Freyc. Voy. p. 356; Hook. & Arn. l. c. p. 103; Hook. Ic. Pl. t. 944; Brack. l. c. p. 10; Hook. l. c. 4, p. 206. Var. bipinnatifidum; Hook. Ic. Pl. t. 495. *P. myriocarpum*, Hook. Ic. Pl. t. 84. (M. & B. 179.)

623. Polypodium (Adenophorus) hymenophylloides, Kaulf. Enum. Fil. p. 118; Hook. l. c. 4, p. 228. *Adenophorus*, Hook. & Grev. Ic. Fil. t. 176. *A. minutus*, Gaud. Bot. Freyc. Voy. p. 365, t. 8, f. 3. (M. & B. 276.)

624. Polypodium (Adenophorus) tamariscinum, Kaulf. Enum. Fil. p. 117; Brack. l. c. p. 12; Hook. l. c. 4, p. 228. *a. Adenophorus Tamarisci*, Hook. & Grev. Ic. Fil. t. 175. *A. bipinnatus*, Gaud. Bot. Freyc. Voy. p. 365, t. 8, f. 2; Hook. & Grev. l. c. t. 174. *β. A. tripinnatifidus*, Gaud. l. c. p. 365, t. 8, f. 1. *P. tripinnatifidum*, Brack. l. c. p. 13. (M. & B. 198; Remy, 15, 16.)

625. Polypodium (Adenophorus) tripinnatifidum, Presl. *P. Hillebrandii*, Hook. l. c. 4, p. 228, t. 279, A? (M. & B. 199.)

626. Polypodium (Adenophorus) abietinum, Eaton (sp. nov): "parvum, delicatulum, glandulis clavatis rubris conspersum, caudice paleaceo brevi repente; rhachi flexuosa subcapillacea; frondibus ovato-oblongis pinnatis; pinnis oblongis ad costam capillaceam pinnatisectis; segmentis 9–15 anguste spathulatis venulam unicam ad apicem soriferam excipientibus; soris latitudinem segmentorum multo excedentibus. — Hawaii (Brackenridge, mixed with *P. hymenophylloides*); Oahu, or trees 3,000 feet above the sea (D. D. Baldwin); Hanalei, Kauai (M. & B.). — Fronds 1–3 inches high, very delicate, apparently bipinnate, the pinnules less than a line long, and about one sixth of a line broad, the sorus near the end, and nearly three times the width of the pinnule. Perfectly distinct from *P. hymenophylloides*, and much more delicate than *P. tamariscinum*, from which its hairlike flexuous rachis will also distinguish it." *Eaton, mss.*

627. Polypodium atropunctatum, Gaud. Bot. Freyc. Voy. p. 346; Hook. & Arn. l. c. p. 103. *Pleopeltis elongata*, Kaulf. *Drynaria elongata*, Brack. l. c. p. 42. — Hooker, l. c. 5, p. 57 unites this and many other supposed species under *P. loriforme*, Wall. (M. & B. 177; Remy, 5.)

628. Polypodium Spectrum, Kaulf. Enum. Fil. p. 94; Hook. & Arn. l. c. p. 103; Hook. l. c. 5, p. 74. *Drynaria Spectrum*, J. Sm.; Brack. l. c. p. 46. *Polypodium Thouinianum*, Gaud. Bot. Freyc. Voy. p. 345, t. 5, f. 1. (M. & B. 154.)

629. Gymnogramme Javanica, Bl. Fil. Jav. p. 95, t. 41; Hook. l. c. 5, p. 145. *G. pilosa*, Brack. l. c. p. 22, t. 4. (M. & B. 486.)

630. Vittaria rigida, Kaulf. Enum. Fil. p. 193; Brack. l. c. p. 61; Hook. l. c. 5, p. 184. *V. plantaginea*, Hook. & Grev. Ic. Fil. t. 187; Gaud. Bot. Freyc. Voy. p. 382. (M. & B. 146.)

631. Acrostichum conforme, Sw. Syn. Fil. p. 10 & 192, t. 1, f. 1; Hook. l. c. 5, p. 198. *A. æmulum*, Kaulf. Enum. Fil. p. 63? *Elaphoglossum æmulum*, Brack. l. c. p. 71. (M. & B. 507.)

632. Acrostichum micradenium, Fée, Acrost. p. 43, t. 8, f. 1; Hook. l. c. 5, p. 216. *Elaphoglossum nitidum*, Brack. l. c. p. 70, t. 9. *Elaphoglossum pellucidum*, Gaud. Bot. Voy. Bonite, t. 79, f. 5–7? (M. & B. 544.)

633. Acrostichum squamosum, Sw. in Schrad. Journ. 1800, 2, p. 11, & Syn. Fil. p. 10; Hook. l. c. 5, p. 239. *A. splendens*, Bory, in Willd. Spec. 5, p. 104; Gaud. Bot. Freyc. Voy. p. 303; Hook. & Arn. l. c. p. 103. *A. crassifolium*, Gaud. Bot. Freyc. Voy. p. 303? *Elaphoglossum splendens*, Brack. l. c. p. 68. (M. & B. 493.)

734. Acrostichum (Olfersia) gorgoneum, Kaulf. Enum. Fil. p. 63 (non Bl.); Hook. l. c. 5, p. 254. *Elaphoglossum gorgoneum*, Brack. l. c. p. 74. (M. & B. 286.)

635. Acrostichum (Chrysodium) reticulatum, Kaulf. Enum. Fil. p. 64; Brack. l. c. p. 81; Hook. l. c. 5, p. 267. *Elaphoglossum reticulatum*, Gaud. Bot. Voy. Bonite, t. 79, f. 1–4. (M. & B. 182.)

636. Hymenophyllum recurvum, Gaud. Bot. Freyc. Voy. p. 376; Hook. & Arn. l. c. p. 109; Hook. l. c. 1, p. 104, t. 37, C; Brack. l. c. p. 269. (M. & B.)

637. Hymenophyllum lanceolatum, Hook. & Arn. l. c. p. 109; Hook. l. c. 1, p. 94, t. 34, B; Brack. l. c. p. 263. (M. & B. 551.)

638. Hymenophyllum obtusum, Hook. & Arn. l. c. p. 109; Hook. l. c. 1, p. 93, t. 33, D; Brack. l. c. p. 263. (M. & B. 281.)

639. Trichomanes parvulum, Poir. ex Kaulf. Enum. Fil. p. 260, fide Brack. l. c. p. 250. *T. saxifragoides*, Presl? (M. & B. 548.)

640. Trichomanes radicans, Sw. Syn. Fil. p. 143?; Hook. l. c. 1, p. 125?; Brack. l. c. p. 254? *T. Sandwicense*, v. d. Bosch. (M. & B. 164.)

641. Trichomanes meifolium, Bory, in Willd. Spec. 5, p. 509; Hook. l. c. 1, p. 137; Brack. l. c. p. 259. (M. & B. 275.)

642. Trichomanes Draytonianum, Brack. l. c. p. 252, t. 36. (M. & B.; Remy, 53.)

643. TRICHOMANES ———? An apparently undescribed species, but not fruiting, and therefore the genus doubtful. (M. & B. 545.)

644. OPHIOGLOSSUM ELLIPTICUM, Hook. & Grev. Ic. Fil. t. 40, A; Hook. Bot. Misc. 3, p. 217; Brack. l. c. p. 314.

645. OPHIOGLOSSUM CONCINNUM, Brack. l. c. p. 315, t. 44.

646. OPHIOGLOSSUM PENDULUM, Linn. ex Sw. Syn. Fil. p. 170; Hook. & Arn. l. c. p. 102; Brack. l. c. p. 316. (M. & B. 139; Remy, 60.)

647. BOTRYCHIUM SUBBIFOLIATUM, Brack. l. c. p. 317, t. 44. (H. Mann.)

648. MARATTIA ALATA, Sw. Syn. Fil. p. 168; Hook. & Arn. l. c. p. 102; Brack. l. c. p. 311. *Stibasia Douglasii*, Presl, Suppl. Tent. Pterid. p. 16. (M. & B. 271; Remy, 57.)

649. SCHIZÆA AUSTRALIS, Gaud. Bot. Freyc. Voy. p. 296; Brack. l. c. p. 302. *S. palmata*, Montagne, Bot. Voy. Astrol. & Zelee, t. 4. f. Z. sine descr. (M. & B. 475.)

Lycopodiaceæ.

650. PSILOTUM TRIQUETRUM, Sw. Syn. Fil. p. 187; Hook. & Arn. Bot. Beech. Voy. p. 102; Brack. Fil. U. S. S. Pacif. Expl. Exp. p. 319; Spring, in Mem. Acad. Brux. 24, p. 269. *Bernhardia dichotoma*, Willd.; Gaud. Bot. Freyc. Voy. p. 290. (M. & B. 140; Remy, 65.)

651. PSILOTUM COMPLANATUM, Sw. l. c. p. 188 & 414, t. 4, f. 5; Spring, l. c. p. 271; Brack. l. c. p. 319; Hook. & Arn. l. c. p. 102. *Bernhardia complanata*, Willd. (M. & B.)

652. LYCOPODIUM POLYTRICHOIDES, Kaulf. Enum. Fil. p. 6; Spring, l. c. p. 32, & 15, p. 73. Brack. l. c. p. 323. *L. verticillatum*, Spring, l. c. 15, p. 46 (pro Ins. Haw.). (M. & B. 549.)

653. LYCOPODIUM VARIUM, Hook. fil. Bot. Ant. Voy. p. 115 (ex parte); Spring, l. c. 24, p. 24, non Spring, l. c. 15, p. 57. *L. sulcinervium*, Brack. l. c. p. 322; Spring, l. c. 15, p. 39. (M. & B. 147; Remy, 73.)

654. LYCOPODIUM PACHYSTACHYON, Spring, in Gaud. Bot. Voy. Bonite, t. 34; Spr. in Mem. Acad. Brux. 15, p. 66, and 24, p. 29; Brack. l. c. p. 326. *L. phyllanthon*, Hook. and Arn. l. c. p. 102; Spring, l. c. 15, p. 73. (M. & B. 135.)

655. LYCOPODIUM NUTANS, Brack. l. c. p. 327. (M. & B. 150.)

656. LYCOPODIUM PHLEGMARIA, Linn., var., or perhaps a distinct species, as it differs in a few particulars. (M. & B. 506.)

657. Lycopodium fastigiatum, R. Br. Prodr. 1, p. 163; Spring, l. c. 15, p. 88, & 24, p. 41. *L. heterophyllum*, Hook. & Grev. Ic. Fil. t. 113 (non Willd.); Spr. l. c. 15, p. 88; Brack. l. c. p. 330.

658. Lycopodium venustulum, Gaud. Bot. Freyc. Voy. p. 285, t. 22; Spring, l. c. 15, p. 84; Brack. l. c. p. 329.

659. Lycopodium cernuum, Linn.; Spring, l. c. 15, p. 79, & 24, p. 37. *L. curvatum*, Bl. Enum. Pl. Jav. 2, p. 266; Gaud. Bot. Freyc. Voy. p. 284 (non. Sw.); Brack. l. c. p. 325 (non. Sw.). (M. & B. 176; Remy, 68.)

660. Lycopodium Haleakalæ, Brack. l. c. p. 321, t. 45.

661. Lycopodium erubescens, Brack. l. c. p. 320, t. 45.

662. Lycopodium volubile, Forst. Prodr. Ins. Aust. p. 86, n. 482; Spring, l. c. 15, p. 105, & 24, p. 49.

663. Selaginella arbuscula, Spring, l. c. 24, p. 183; Brack. l. c. p. 332. *Lycopodium Arbuscula*, Kaulf. Enum. Fil. p. 19; Gaud. Bot. Freyc. Voy. p. 288; Hook. & Arn. l. c. p. 102. (M. & B. 174.)

664. Selaginella Springii, Gaud. Bot. Voy. Bonite, t. 12; Spring, l. c. 24, p. 184.

665. Selaginella Menziesii, Spring, l. c. 24, p. 185. *Lycopodium Menziesii*, Hook. & Grev. Enum. Fil. n. 131; Hook. & Arn. l. c. p. 102; Brack. l. c. p. 333. *Lycopodium Arbuscula*, Hook. & Grev. Icon. Fil. t. 200, non Kaulf. (M. & B. 175.)

666. Selaginella deflexa, Brack. l. c. p. 332, t. 45. (M. & B. 474.)

Hydropterides.

667. Marsilea villosa, Kaulf. Enum. Fil. p. 272; Brack. l. c. p. 341. *M. vestita*, Hook. & Grev. Ic. Fil. t. 159. *M. quadrifolia*, Gaud. Bot. Freyc. Voy. p. 406. *M. hirsuta*, R. Br. Prodr. p. 167? (Remy, 63.)

The Mosses and Hepaticæ may form the subject of some future communication.

LICHENES.* (By Edw. Tuckerman.)

Trib. I. Parmeliacei, Fr.

Fam. 1. *Usneei.*

SIPHULA PICKERINGII, Tuckerm. (Bot. U. S. S. Pacif. Expl. Exp.) Appears scarcely referable to *S. torulosa* (Thunb.) to which Nylander (Lich. exot.) has referred it; but possibly to *S. pteruloides*, Nyl. l. c., a Peruvian Lichen. — On the earth, among mosses, Oahu (Pickering), Tuck. l. c.

RAMALINA MANNI (sp. nov.): thallo subfoliaceo depressó lacero-laciniato glauco, subtus nigricante, laciniis lacunosis margine eroso-denticulatis, fertilibus suberectis; apotheciis podicellatis margine evanido. Sporæ octonæ in thecis, parvæ, diblastæ, curvulæ, diam. 2 – 2½ plo longiores, incolores. — Trunks, Makawao, East Maui (Mann). — Exhibits a close approach to the foliaceous thallus of *Cetraria;* and the depressed habit and differently-colored sides are new to the present genus, with which it is none the less associated by the characters of fructification. The rather short, lacunose, and, especially when fertile, ascendant lobes are about one quarter of an inch in diameter; the apothecia reach the same size. Spores .013 – .014^{mm} long.

RAMALINA LÆVIGATA, Fr. — Trunks, Mountains of Kauai (Mann).

RAMALINA CALICARIS (L.) Fr., var. FRAXINEA, Fr. —Trunks, Oahu (Mann). Var. FARINACEA, Schær.? *R. complanata*, Ach.? — Hawaii (Pickering), Tuck. l. c. Var. INFLATA. *R. inflata*, Hook. — Trees, Kaala Mountains, Oahu (Mann).

USNEA BARBATA (L.) Fr., var. FLORIDA. Fr. — Trunks, Hawaiian Islands, Nyl., Tuck.; as also in the form MICROCARPA (Pers., e Gau-

* The list is meant to include all that is known of the Lichen-Flora of the Islands. This makes part only of a larger Flora, the limits of which are scarcely settled; and is not to be understood without constant reference to what has been determined of the latter. Montagne and Jardin have illustrated portions of the wider field; and Dr. Nylander has combined their results with important ones of his own, in his *Lichenes Polynesienses*, which makes the second part of his *Lichenes exotici* (Ann. Sci. Nat. 4, 11). Besides this enumeration, reference is made in what follows to the list of Lichens (prepared by the present writer) in the Botany of the U. S. S. Pacif. Expl. Exp. It is scarcely to be doubted that other Lichens, cited as Polynesian, have been determined by European Lichenists in specimens from the Sandwich Islands, and among these some of those here credited to Mr. Mann may well occur: but the catalogue will still show how large a proportion of our knowledge, especially in the crustaceous groups, is due entirely to his researches; — directed, as these were, by previous study of North American Lichens.

dichaud) Nyl. l. c.; (Mann.) Var. HIRTA f. RUBIGINEA. — Trees, Mountains of Kauai (Mann). Var. CERATINA, Schær. — Trunks, Hawaiian Islands (Remy), Nyl. l. c.

Fam. 2. Parmeliei.

THELOSCHISTES CHRYSOPHTHALMUS, var. FLAVICANS, Wallr. — Oahu & Hawaii (Pickering), Tuck. l. c.; mountains of Kauai and Maui (Mann).

PARMELIA PERLATA (L.) Ach., var. OLIVETORUM, Ach. — Hawaiian Islands (Hillebrand). Var. CILIATA, Schær. — Hawaiian Islands, Nyl. l. c.; (Mann).

PARMELIA PERFORATA (Jacq.) Ach. — Oahu (Meyen), Herb. Berol. Hawaii (Pickering), Tuck. l. c.; (Mann).

PARMELIA LÆVIGATA (Sm.) Ach. — Trunks, Hawaii (Pickering), Tuck. l. c.; Waialua Mountains, Oahu (Mann).

PARMELIA CERVICORNIS, Tuck. — Trunks, Hawaii (Pickering), Tuck. l. c.; East Maui, 7,000 feet alt. (Mann).

PARMELIA TILIACEA (Ehrh.) Floerk. — A fragment perhaps referable here. — Oahu (Mann).

PARMELIA PERTUSA (Schrank.) Schær. — Hawaiian Islands; Nyl. l. c. — Oahu (Mann).

PARMELIA CAPERATA (L.) Ach. — Hawaiian Islands (Remy), Nyl. l. c.; Mouna Kea, Hawaii (Pickering), Tuck. l. c.

PARMELIA CONSPERSA (Ehrh.) Ach. — Rocks, East Maui and Mauna Kea, Hawaii (Pickering), Tuck. l. c.; Hualalai, Hawaii, 6,000 feet alt. (Mann).

PHYSCIA SPECIOSA (Wulf., Fr.) var. HYPOLEUCA, Ach. f. HYPOMELA. — Trees, mountain of West Maui (Mann). Var. OBESA. *P. obesa* (Pers.) Nyl. *P. papulosa*, Mont. — Mountain of West Maui (Mann). Var. LEUCOMELA, Eschw. — Hawaii (Pickering), Tuck. l. c.; (Hillebrand).

PHYSCIA STELLARIS (L.) var. ASTROIDEA, Tuck., forma. — Lava, Oahu (Mann).

PHYSCIA PICTA (Sw.) Nyl. — Trunks, common (Mann).

PYXINE COCOES (Sw.) Nyl. — Trunks, Oahu (Mann).

Fam. 3. Umbilicariei.

UMBILICARIA VELLEA (L.) Fr., *e habitu.* — Rocks, region of *Sophora*, Mauna Loa, Hawaii, infertile (Pickering), Tuck. l. c.

Fam. 4. Peltigerei.

STICTA CRENULATA (Hook.) Del. — Trunks, Hawaiian Islands (Gaud.), Nyl. l. c.; West Maui and other islands, abundant (Mann).

STICTA ORYGMÆA, Ach. *S. flavicans* Tayl. *S. Durvillei*, var. *flavicans*, Nyl. — Trees, mountain of West Maui (Mann).

STICTA AURATA (Sm.) Ach. — Trees, Oahu (Mann).

STICTA MOUGEOTIANA, Del., Nyl. — Hawaiian Islands (Gaud.), Nyl. l. c.

STICTA CROCATA (L.) Ach. — Walls of crater, East Maui and Hawaii (Pickering), Tuck. l. c.; mountain of West Maui, fertile (Mann).

STICTA ARGYRACEA (Bor.) Del., Nyl. — Oahu (Mann).

STICTA QUERCIZANS (Michx.) Ach., Nyl. — Near Hilo, Hawaii (Pickering), Tuck. l. c.; Oahu (Mann). Var LUTESCENS, Nyl. — Hawaiian Islands (Gaud.), Nyl. l. c.; Oahu (Mann).

STICTA AMBAVILLARIA (Bor.) Del. — Hawaiian Islands (Remy), Nyl. l. c.; Hawaii, Oahu, and West Maui, 3,000 - 5,000 feet alt. (Mann).

STICTA FILIX (Sw.) *S. filicina*, Ach. — Oahu (Mann).

NEPHROMA TOMENTOSUM (Hoffm.) Koerb., var. HELVETICUM, Fr. — Trunks, Oahu, and mountain of West Maui (Mann).

NEPHROMA LÆVIGATUM, Ach., var. RUFUM, Babingt. — Trunks, Oahu (Mann).

PELTIGERA RUFESCENS, Hoffm. — Hawaiian Islands (Remy), Nyl. l. c. Walls of crater, East Maui (Pickering), Tuck. l. c.; Hawaii (Mann).

PELTIGERA POLYDACTYLA, Hoffm. — Hawaiian Islands (Remy), Nyl. l. c.; Hawaii, and Kaala Mountains, Oahu (Pickering), Tuck. l. c.; Oahu (Mann).

ERIODERMA UNGUIGERUM (Bor.) Nyl. — Trees, Oahu (Mann).

Fam. 5. Pannariei.

PANNARIA MOLYBDÆA (Pers.) *Coccocarpia parmelioides*, Tuck. in Wright, Lich. Cub. — Trees, Oahu (Mann).

PANNARIA LURIDA (Mont.) Nyl. — Trees, Hawaiian Islands (Gaud.), Mont. Bot. Voy. Bonite (Mann). Var. HYPOMELA. — Hawaiian Islands (Hillebrand; Mann).

PANNARIA PANNOSA (Sw.) Del. — Trees, Hawaiian Islands (Gaud.),

Nyl. l. c. (Hillebrand). Common on trunks at low and medium altitudes (Mann).

Pannaria rubiginosa (Thunb.) Del. — Hawaii (Pickering), Tuck. l. c.; on the earth, summit of Hualalai, Hawaii, 8,000 feet alt., and on trunks (Mann).

Pannaria nigrocincta (Mont.) Nyl. — Oahu (Mann).

Fam. 6. Lecanorei.

Dirina repanda (Fr.) Nyl. — On lava, Oahu (Mann).

Placodium cinnabarinum (Ach.) Anz. — On lava, Oahu (Mann).

Placodium aurantiacum (Lightf.) Næg. & Hepp. — Hawaiian Islands (Remy), Nyl. l. c.

Placodium albidellum (sp. nov.): thallo areolato-verruculoso glaucescente; apotheciis minutis sessilibus demum lutescentibus, disco plano pulverulento, margine obtuso. Sporæ octonæ in thecis, mediocres, polari-diblastæ, diam. 2 – 3 plo longiores, incolores. — On lava, Oahu (Mann). — The rather obscure yellowish tinge at length observable in the simple exciple is the only external feature associating this Lichen with the group to which its spores refer it.

Placodium Brebissonii (Fée, sub *Lecidea*). *Lecanora*, Nyl. — Hawaiian Islands (Remy), Nyl. l. c.

Placodium spadiceum (sp. nov.): thalli granulis mox isidiomorpho-elongatis adscendentibus ramulosis dein stipatis cinereo-fuscescentibus; apotheciis mediocribus biatorinis sessilibus, disco plano castaneo nudo, margine tenui elevato pallidiori subintegro, thallino obsolescente. Sporæ octonæ in thecis, mediocres, ellipsoideæ, polari-tetrablastæ, diam. 2 – 3 plo longiores. — Trunks, Oahu (Mann). — Agrees with the last species in exhibiting the highest known modification of its type of spore, but differs remarkably in the isidioid evolution of its thallus, and in the colors. The North American *P. camptidium* is perhaps best comparable in the latter respect.

Lecanora pallescens (L.) Schær. — Trunks, Oahu (Mann).

Lecanora glaucoma, Ach. — Volcanic rocks, Oahu (Mann).

Lecanora subfusca (L.) Ach. — Oahu (Mann).

Lecanora granifera, Ach. — Trunks, Oahu (Mann).

Lecanora punicea, Ach. — Trunks, Oahu (Mann).

Rinodina sophodes (Ach.) — Volcanic rocks, Oahu (Mann).

Rinodina mamillana (sp. nov.): thallo subtartareo rimoso-areo-

lato pallide stramineo, hypothallo nigricante; apotheciis minutis sessilibus lecanorinis, margine obtuso mox fusco-nigricante, disco concolore papillato, demum rugoso-plicatis. Sporæ octonæ in thecis, parvæ, obtusissime ellipsoideæ, diblastæ, diam. subduplo longiores, fuscæ.—Volcanic rocks, Oahu (Mann).—Apothecia at length rather elevated, and curiously contorted; illustrating, both in this respect and in their decoloration, those of *Umbilicaria*.

PERTUSARIA VELATA (Turn.) Nyl. Scand., the states resembling Lindig, Lich. N. Gran. n. 2,658.—Trees, Waialua Mountains, Oahu (Mann).

PERTUSARIA WULFENII, DC.—Volcanic rocks, Oahu (Mann).

PERTUSARIA LEIOPLACA (Ach.) Schær.—Trunks, Oahu (Mann).

GYALECTA LUTEA (Dicks.) Tuck.—Hawaiian Islands (Remy), Nyl. l. c.; Oahu, Lanai (Mann).

URCEOLARIA CINEREO-CÆSIA (Sw.) Ach.—On the earth, Kaala Mountains, Oahu (Mann).

URCEOLARIA ACTINOSTOMA, Pers.—Volcanic rocks, Oahu (Mann).

THELOTREMA CALVESCENS, Fée.—Trunks, Oahu (Mann).

THELOTREMA TEREBRATUM, Ach.—Trees, Oahu (Mann).

THELOTREMA CAVATUM, Ach., Nyl., var.—Trunks, Oahu (Mann).

THELOTREMA PILULIFERUM (sub-sp. nov.): thallo subtartareo contiguo l. æquabili l. verruculoso glaucescente albidove cum hypothallo confuso; apotheciis confertis superficialibus globularibus subclausis, excipulo exteriori apice poro pertuso proprium integrum fuscum fovente, disco concavo pallido. Sporæ octonæ, cocciformes, muriformes (ser. transv. dein 6, long. 2–3) diam. subduplo longiores, incolores.—Trees, Oahu (Mann).—With quite the aspect, in some of the specimens, of a *Pertusaria*, not remote from conditions of *P. velata*. The Lichen is evidently closely allied to *Thelotrema pachystomum*, Nyl. (Wright, Lich. Cub. n. 131; Lindig, herb. N. Gran. n. 55, 88, coll. 2[dae]) from which it especially differs in its cocciform, muriform-plurilocular spores; the spores of the other being regularly quadilocular, and affording no indications of ulterior development. But both alike of these decolorate spore-forms belong, we believe, to the colored type; and in fact one of them expresses what is exactly the younger condition of the other. The discrepancy in shape and in the measurements between the spores of the Oahu Lichen, and those of the West Indian and South American ones appears to be due entirely to the *distention* which so commonly accompanies the evolution of the muriform stage.

It appears therefore likely, the general agreement between these plants being undeniable, that they express only conditions of the same species.

THELOTREMA LEUCOMELANUM, Nyl. — Trunks, Oahu (Mann).

THELOTREMA BAHIANUM, Ach. — Trunks, mountain of West Maui, and Oahu (Mann).

THELOTREMA AUBERIANUM, Mont. — Trunks, Oahu (Mann).

THELOTREMA LEPADODES, Tuck. — Trees, Oahu (Mann.)

Trib. II. Lecideacei, Fr.

Fam. 1. *Cladoniei.*

STEREOCAULON RAMULOSUM (Sw.) Ach., f. PROXIMUM. *S. proximum*, Nyl. — Walls of crater, East Maui (Pickering), Tuck. l. c.; Kaala Mountains, Oahu (Mann). — The greater or less elongation of the nodules in the gonimous layer of the cephalodia scarcely affords a satisfactory difference.

STEREOCAULON MIXTUM, Nyl. — Hawaiian Islands (Gaud.), Nyl. l. c.; mountains of Oahu (Andersson), Th. Fr. — The series of forms, — including the East Indian *S. piluliferum*, Th. Fr., the oldest and most significant name, — brought together here by Dr. Nylander, has been shown by him to be marked by a curious difference in the structure of the gonimous layer of the cephalodia. In other respects there is little to distinguish these forms from *S. ramulosum;* and even the dwarfed and otherwise noticeable lichen of the Himmalayah (Herb. Hook.; Hook. & Thoms. herb. Ind. Or.) well compares with a similarly small condition (Oahu, Mann; comp. *S. claviceps*, Th. Fr., Nyl.) of the latter.

STEREOCAULON PILOPHOROIDES, Tuck. — Hawaiian Islands (Hillebrand).

CLADONIA PYXIDATA (L.) Fr. — East Maui (Pickering), Tuck. l. c.

CLADONIA GRACILIS, var. ELONGATA, Fr. — Mauna Loa, Hawaii (Pickering), Tuck. l. c.

CLADONIA FIMBRIATA (L.) Hoffm. — Hawaii (Pickering), Tuck. l. c. Var. ADSPERSA, Tuck. — Hawaii (Mann).

CLADONIA FURCATA (Schreb.) Fr. — Hawaii (Pickering), Tuck. l. c.; Waialua Mountains, Oahu (Mann).

CLADONIA SQUAMOSA, Hoffm. — Hawaii (Pickering), Tuck. l. c.

CLADONIA RANGIFERINA (L.) Hoffm. — Hawaiian Islands, Nyl.; Mauna Loa, Hawaii, and Kaala Mountains, Oahu (Pickering), Tuck. l. c.; Mountain of West Maui, etc. (Mann).

Cladonia angustata, Nyl. — Hawaiian Islands (Remy), Nyl. l. c.; Hawaii and Lanai (Mann).

Cladonia macilenta (Ehrh.) Hoffm. — Hawaiian Islands, Montagne; Mountain of West Maui (Mann).

Cladonia muscigena, Eschw. — Hawaiian Islands (Remy), Nyl. l. c.; Hawaii (Pickering), Tuck. l. c.; West Maui (Mann).

Fam. 2. *Lecideei.*

Bæomyces fungoides (Sw.) Ach. — Mountain of West Maui, on the earth (Mann).

Biatora aurigera (Fée). — Trunks, Oahu (Mann).

Biatora cyrtelloides (Nyl.) — Hawaii (Remy), Nyl. l. c.

Biatora triseptata (Hepp.) Mont. & v. d. Bosch. — On the earth, Mountain of West Maui (Mann).

Biatora rubella (Ehrh.) Rabenh., var. (*spadiceæ, aff.*) — Trunks, Waialua Mountains, Oahu (Mann). Var. incompta, Nyl. — Hawaiian Islands, Nyl. l. c.

Heterothecium Taitense, Mont. — Trunks, Oahu, and West Maui, very common (Mann).

Heterothecium Domingense (Pers.) *H. gyrosum*, Flot. — Trunks, Oahu (Mann).

Heterothecium leucoxanthum (Spreng.) *H. tricolor*, Flot., Mont. — Hawaiian Islands, Nyl.; Oahu, and East Maui (Mann).

Lecidea trachonoides, Nyl. Lich. N. Caled., *e descr.* — Trunks, Mountain of West Maui, and Oahu (Mann).

Buellia parasema (Ach.) Koerb. — Mountain of West Maui (Mann). Var. œruginascens, Nyl. — Trees, Oahu (Mann). — Var. endococcina, Tuck. — With the last (Mann).

Buellia atroalba (Ach., Flot.) Th. Fr. — Volcanic rocks, Oahu (Mann).

Trib. III. Graphidacei, Eschw., Fr., Nyl.

Fam. 1. *Lecanactidei.*

Lecanactis premnea (Ach.) Tuck. — Trunks, Waialua Mountains, Oahu (Mann).

Fam. 2. *Opegraphei.*

Opegrapha subcentrifuga, Nyl. — Trunks, Hawaii (Remy), Nyl. l. c.

OPEGRAPHA ATRA, Pers. — Trees, Hawaii (Remy), Nyl. l. c.; Oahu (Mann).

OPEGRAPHA LENTIGINOSA, Lyell. — Trees, Oahu (Mann).

GRAPHIS SCRIPTA (L.) Ach., *emend.* — Trees, Oahu (Mann). — Var. ASSIMILIS. *G. assimilis*, Nyl. — Oahu (Mann).

GRAPHIS DISCURRENS, Nyl., var. KAALENSIS: apotheciis crassioribus dendritico-ramosis; sporis (octonis) majoribus 8-blastis. — Trunks, Kaala Mountains, Oahu (Mann). — A larger plant than the Lichen (Hong Kong, Wright) described by Nylander, and with rather the aspect of conditions of *G. vernicosa*, Fée.

GRAPHIS ELEGANS (Sw.) Ach. f. STRIATULA. *G. striatula*, (Ach.) Nyl. — Trunks, Oahu (Mann). Var. SUBSTRIATULA. *G. substriatula*, Nyl. — With the last (Mann).

GRAPHIS RIGIDA (Fée) Nyl. — Trees, Oahu (Mann).

GRAPHIS FULGURATA, Fée, *e descr.* — Trees, Oahu (Mann). — Small, with a little of the aspect of *G. discurrens*, *a*, the colored spores of which species also look towards the section represented by *G. dendritica;* but approaching more evidently to the latter, with which it was arranged by Fée, in its open disk.

GRAPHIS DENDRITICA, Ach., *excip integro.* — Trees, Waialua Mountains, Oahu; and Hawaii (Mann). Var. INUSTA. *G. inusta*, Ach., Nyl. — With the last, Oahu (Mann). Var. LEUCOCHEILA. *G. leucocheilæ* (Fée) Nyl. *prox. accedens.* — Trees, Kaala Mountains, Oahu (Mann). — The Oahu Lichen last named has the habit of large forms of *G. scalpturata*, Ach., in which the thalline margin is conspicuous (Lindig, Lich. N. Gran. n. 54, coll. 2[dae]) but the spores of *G. dendritica;* differenced here, as commonly in the Carolina Lichen, by an occasional passage of one or more of the sporoblasts into two, — the beginning of the muriform-multilocular stage. And it certainly suggests that *G. scalpturata* (compare especially the specimen of this in Lindig's n. 752 with that of *G. dendritica* in n. 2,563 of the same collection) is only a condition (the ultimate one as respects sporal development) of *G. dendritica;* analogous to *G. scripta*, var. *sophistica.* (*G. sophistica*, Nyl.)

GRAPHIS PATELLULA (Meissn.) Nyl. *in litt.* *Opegrapha*, Meissn. in Fée Suppl., *Lecanactis*, Nyl. Enum. Var. PATERELLA. *Lecanactis*, Tuck. *in litt.* — Trees, Oahu (Mann). — Spores (as in the Carolina Lichen) 8 – 10-locular. Those of Fée's Lichen are described by him as 15 – 18-locular.

GRAPHIS FRUMENTARIA, Fée, var. CHLOROCARPA, Nyl. *G. chlorocarpa*, Fée. — Trunks, Oahu (Mann).

GRAPHIS TUMULATA, Nyl., *e descr.* — Trunks, Oahu (Mann). — Spores brown, cocciform, submuriform (transverse series of sporoblasts four; longitudinal, one to three), as described in the cited species, from New Caledonia.

GRAPHIS OSCITANS (sp. nov.): thallo tenui contiguo æquabili albo; apotheciis innato-prominulis simplicibus subramosisve flexuosis, marginibus excipuli profunde canaliculati nigricantis tenuibus, dein hiantibus nudis, cum thallino crassiusculo concretis, hypothecio incolore. Sporæ octonæ in thecis, mediocres, oblongæ, submuriformes (ser. tr. 6–8, long. 1–2) diam 3–3½ plo longiores, fuscescentes. — Trunks, Oahu (Mann). — With the aspect of the closed apothecia of *G. dimorpha*, Nyl., and agreeing in size; but not assuming the habit of *G. dendritica;* and better comparable with species of the present group.

GRAPHIS GRAMMITIS, Fée. — Trunks, Waimea, Kauai, and mountain of West Maui (Mann). — One of the sporoblasts now divided into two; an indication of the true type of this decolorate spore.

GRAPHIS RADIATA, Nyl. — Trees, Oahu (Mann). — One of the specimens resembling *Fissurina nitida*, M. and v. d. Bosch. *Lich. Jav.*, which I take to be the Java *Gr. radiata* of Nyl. *Enum.*, — the first named authors not having had the advantage of comparing the Lichen with Eschweiler's *Diorygma nitidum;* — and the other smaller, and more like *G. radiata* as published in Lindig's New Granada Lichens. The spores of the forms named scarcely differ. There is still another of these debased types of *Graphis* (Oahu; Mann) intermediate in the size of the apothecia between the coarser and slenderer forms just noticed, but otherwise similar, which is remarkably differenced by the colored (cocciform and regularly quadrilocular) spores; suggesting *G. heterospora*, Nyl., of Bourbon: the only described instance of coloration in the present section (*Fissurina*).

Fam. 3. Glyphidei.

CHIODECTON PERPLEXUM, Nyl. — Trees, Kaala and Waialua Mountains, Oahu (Mann).

GLYPHIS HETEROCLITA, Mont. — Trees, Kaala and Waialua Mountains, Oahu (Mann).

GLYPHIS ACHARIANA, Tuck. Suppl. 1858. *G. cicatricosa* and *G. favulosa*, Ach., and *G. confluens*, Mont. — Trunks, Oahu (Mann).

Fam. 4. *Arthoniei.*

ARTHONIA CINNABARINA (DC.) Wallr.; var. ADSPERSA, Nyl. — Trunks, Hawaiian Islands (Remy), Nyl. l. c.

ARTHONIA CARIBÆA (Ach.) Nyl., forma. — Trees, Oahu (Mann).

ARTHONIA INTERDUCTA, Nyl. — Trees, Oahu (Mann). — Spores 5–7-locular, but all the narrower sporoblasts broken (in these specimens constantly, so far as observed) into smaller ones, and the spores becoming thus submuriform-multilocular; the large terminal sporoblasts remaining entire.

ARTHONIA PLATYGRAPHIDEA, Nyl., *e descr.* — Trees, Oahu (Mann). — Answering well to the described Mexican lichen, and remarkable for its fusiform, 12–15-locular spores in oblong sporesacks, like those of some *Opegrapha.*

ARTHONIA ASTROIDEA, var. SWARTZIANA, Nyl. — Trees, Hawaii (Remy), Nyl. l. c.

Trib. IV. Caliciacei.

ACOLIUM PROTRUDENS. *Tylophoron*, Nyl. — Trunks, Waialua Mountains, Oahu (Mann). — The separation of this type, as of the Californian saxicoline species, from *Acolium*, on account of the distinct, excipular relation of the thallus to the proper exciple, appears to be precluded by the structure, as well of other recognized members of the group (as *A. ocellatum* (Flot.) Koerb.) as especially of *A. tigillare.* These new forms may then be regarded as affording only a better exhibition of the highest view of the generic type, as suggested by the older ones. And ennobled thus, as by the lobulate thallus of *A. Californicum*, the present genus may claim perhaps no uncertain place in the closest affinity to the fruticulose *Acroscyphus.* The Hawaiian specimens agree best with *Tylophoron protrudens*, Nyl., as exhibited in Lindig's N. Granada Lichens, the apothecia being larger than in the *T. moderatum* of the same work; but the latter (Lindig, herb. n. 2,653, 2,891, and 38, coll. 2[dae]) is clearly inseparable, in my view, from the former. In 2,891 (*T. moderatum*) the spores also are smaller than in 2,633 (*T. protrudens*), but in no. 38 though the apothecia are reduced, the spores cease to afford any available difference.

ACOLIUM HAWAIENSE (sp. nov.): thallo tenuissimo glaucescente cum hypothallo albido confuso; apotheciis mediocribus elevatis lecano-

roideo-depressisve, excipulo proprio in thallode crasso margine radiato-rugoso immerso, disco plano purpureo-nigro immarginato. Sporæ octonæ in thecis, minutæ, obtusissime ellipsoideæ, diblastæ, fuscæ. — Trunks, Waialua Mountains, Oahu (Mann). — The interior exciple (white, inner layer of the hypothecium) appears often (as more or less observable also in *A. protrudens*) externally, making a membranaceous, lacerate-denticulate border to the disk; or once again, as in *Thelotrema*, this border disappears, and is represented by a white, powdery, at length irregularly cracked *veil* which conceals the here concave disk. Proper exciple pale, so far as observed, immersed in a thalline wart, the thick border of which is, more or less distinctly, radiately cleft, or striate. Apothecium reaching a line in diameter. Spores averaging only one third of the size of the largest ones of the preceding species, or in length scarcely more than $.006^{mm}$; those of the Hawaiian *A. protrudens* exceeding, at length, $.018^{mm}$.

Acolium Javanicum (Mont. and v. d. Bosch) Stizenb. — Trunks, Oahu (Mann).

Calicium tubæforme (Mass.) *Sphinctrina*, Mass. *S. microcephala*, Nyl. — On thallus of *Pertusaria* sp., Oahu (Mann).

Trib. V. Verrucariacei (Fr. 1821, Fée), Stizenb.

Fam. 1. *Endocarpei.*

Normandina Jungermanniæ (Del.) Nyl. — Growing on *Sticta crenulata* in the mountains of West Maui, and on *Pannaria molybdæa* in Oahu (Mann).

Fam. 2. *Verrucariei.*

Trypethelium pallescens, Fée, Nyl. — Trees, Waialua Mountains, Oahu (Mann).

Pyrenula planiuscula. *Verrucaria*, Nyl., *e descr.* — Trees, Oahu (Mann). — Not unlike *V. insulata*, Fée (*determ.* Nyl.), but with spores of twice the dimensions.

Pyrenula Cinchonæ (Ach. *e* Nyl. N. Gran.) *Verr. prostans*, Mont. — Trees, Oahu (Mann). — Specimens also occur from the same region, belonging apparently to the little cluster of forms which Dr. Nylander (under his *Verr. subprostans*, Pyrenoc. p. 56) has regarded as possibly reducible to a single species. In the size of the spores these specimens approach rather to *V. subprostans*, but in shape to *V.*

viridiseda, Nyl. The whole cluster approaches very closely, it should seem, to *P. Cinchonæ.*

Pyrenula planorbis (Ach.) — Trees, Waialua Mountains, Oahu (Mann).

Pyrenula diluta (Fée). — Trees, Oahu (Mann).

Pyrenula nitida, Ach. var. nitidella, Floerk. — Trunks, Oahu (Mann). — A Lichen also occurs with a white crust, but otherwise allied to this, which I take for *P. Cinchonæ*, Fée, included by Nylander under his *Verr. nitida.*

Pyrenula marginata, Hook. — Trunks, Oahu (Mann). Var. Santensis, Nyl. *Verrucaria*, Tuck. *in litt.* — With the last, from which it differs in its smaller apothecia, and cocciform spores.

Pyrenula leucostoma, Ach. — Trunks, Oahu (Mann). — Identical with a Japanese Lichen determined by Dr. Nylander.

Pyrenastrum astroideum (Fée) Eschw. — Trunks, Oahu (Mann). Var. duplicans, Nyl. — With the last (Mann).

Lichenes Collemacei.

Leptogium tremelloides (Ach.) Fr. — Hawaiian Islands (*L. marianum*, Mont., *e* Nyl.) Nyl. — Oahu (Mann). Var. laciniatum, Tuck. — Oahu (Pickering), Tuck. l. c.; (Mann).

Leptogium saturninum (Dicks.) Nyl. — Trees, Ulapalakua, East Maui (Mann).

Leptogium chloromelum (Sw.) Nyl. — Oahu (Mann).

Leptogium phyllocarpum (Pers.) Nyl. — Oahu (Mann).

Addenda et Corrigenda.

John Miers, in the Annals and Magazine of Natural History, 19, n. 109, Jan. 1867, sustains Loureiro's genus *Nephroica* as distinguished from *Cocculus* by the cleft petals and other characters, and his genus *Holopeira*, distinguished from both the others by the broad, emarginate petals and the peculiar perforated putamen, etc. He then arranges the Hawaiian species (of which he distinguishes three) thus: —

Nephroica ovalifolia, Miers. *Cocculus ovalifolius*, DC. *C. umbellatus*, Steud. Menispermum ovalifolium, Vahl., and refers to a specimen in herb. Brit. Mus., and to Barclay's, 1271. According to him, it also grows in Corea.

Nephroica Ferrandiana, Miers. *Ferrandia oleifolia*, Gaud.,

Cocculus Ferrandianus, Presl. Apparently confined to the Hawaiian Islands.

HOLOPEIRA CONCHOPHYLLA, Miers. *Cocculus Ferrandianus*, Seem. (non Gaud.) Fl. Vitiensis, and refers to specimens in herb. Hook. (Hillebrand) and Seemann's n. 2281.

Myonima umbellata, referred as a synonyme to *Canthium lucidum*, should, according to the specimens (ex Seemann, Fl. Vitiensis), be referred to a *Straussia*.

Under number 400, for *S. Freyienetianum* read *S. Freycinetianum*.

Under number 312, insert (M. & B. 40); 324, insert (M. & B. 305); 489, insert (M. & B. 36).

After 422 insert 422[a]. EUXOLUS VIRIDIS, Moq. l. c. p. 273. (M. & B. 67).

Five hundred and seventy-second Meeting.

October 9, 1866. — MONTHLY MEETING.

The PRESIDENT in the chair.

Professor Horsford presented a communication on the popular doctrine that sunlight retards combustion.

Professor Henry presented a communication on the causes and physical nature of fogs, and on the means of warning vessels, befogged on our coasts, by sound-signals.

Five hundred and seventy-third Meeting.

November 14, 1866. — STATUTE MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary read letters relative to exchanges; also letters from Professor Noah Porter of Yale College, Chief Justice Ira Perley of New Hampshire, and Dr. A. W. Chapman of Apalachicola, in acknowledgment of their election into the Academy as Associate Fellows.

The President called the attention of the Academy to the recent decease of Mr. Samuel Swett of the Resident Fellows.

The President announced that since the last meeting Mr. George Peabody had founded an important institution for the

advancement of American Archæology and Ethnology, and had included the President of this Academy in the trust. He read the letter and deed of trust from Mr. Peabody, and suggested that they should be copied into the records.

Professor Agassiz spoke at length upon the great importance of this new establishment, and offered the following resolutions: —

"*Resolved,* That the documents now presented by the President relative to the foundation by Mr. George Peabody of a Museum and Professorship of American Archæology and Ethnology be entered upon the records of the Academy.

"*Resolved,* That the Academy with much satisfaction recognizes the sagacity and liberality of Mr. Peabody in providing these means and inducements for the investigation of subjects of especial interest to us as Americans, and of universal interest to all inquirers into the nature of man and the records of his growth and development.

"*Resolved,* That the Academy gladly acknowledges, as among the duties of its President, those which devolve upon him as an *ex officio* trustee of Mr. Peabody's foundation."

The resolutions were unanimously adopted.

The Treasurer's accounts for the year ending at the last Annual Meeting, approved by the Auditing Committee, were received and ordered to be entered upon the record.

Professor Lovering as Chairman of the Committee of Publication moved a special appropriation of five hundred dollars to complete the publication of Dr. Storer's Memoir on the Fishes of Massachusetts; and the motion was referred to the Finance Committee.

The following gentlemen were elected members of the Academy: —

Dr. James D. Whelpley, to be Resident Fellow in Class I. Section 3.

Dr. Henry W. Williams, to be Resident Fellow in Class II. Section 4.

Mr. John M. Batchelder, to be Resident Fellow in Class I. Section 4.

Mr. William Gray, to be Resident Fellow in Class III. Section 3.

Dr. James C. White, to be Resident Fellow in Class II. Section 3.

Mr. J. Eliot Cabot, to be Resident Fellow in Class III. Section 4.

Mr. William R. Ware, to be Resident Fellow in Class I. Section 4.

Dr. Frederic H. Hedge, to be Resident Fellow in Class III. Section 1.

Mr. Charles Dean, to be Resident Fellow in Class III. Section 3.

Dr. Isaac Ray of Philadelphia, to be Associate Fellow in Class III. Section 1.

Henry Sumner Maine, to be Foreign Honorary Member in Class III. Section 1, in place of the late Dr. Whewell.

Professor Peirce presented by title an investigation on "Linear Algebra."

Five hundred and seventy-fourth Meeting.

November 21, 1866. — SPECIAL MEETING.

The PRESIDENT in the chair.

The President called the attention of the Academy to the recent decease of Rev. Dr. William Jenks of the Resident Fellows.

Dr. J. Bigelow read a paper on "Classical and Utilitarian Studies."

Five hundred and seventy-fifth Meeting.

December 11, 1866. — MONTHLY MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary read letters relative to exchanges.

Dr. Kneeland read a communication on certain fungoid parasites which grow from the bodies of insects.

Mr. G. W. Hill gave an account of the present state of the Lunar Theory.

Mr. T. S. Hunt presented some theoretical considerations in explanation of the chemical activity of substances in the "Nascent State."

Five hundred and seventy-sixth Meeting.

January 8, 1867. — Monthly Meeting.

The President in the chair.

The Corresponding Secretary read letters relating to exchanges; also an invitation to the members of this Academy from the Imperial Mineralogical Society of St. Petersburg, to attend the fiftieth anniversary of its foundation.

The following communication was presented: —

On the Object and Method of Mineralogy. By T. Sterry Hunt, F. R. S.

Mineralogy, as popularly understood, holds an anomalous position among the natural sciences, and is by many regarded as having no claims to the rank of a distinct science, but as constituting a branch of chemistry. This secondary place is disputed by some mineralogists, who have endeavored to base a natural-history classification upon such characters as the crystalline form, hardness, and specific gravity of minerals. In systems of this kind, however, like those of Möhs and his followers, only such species as occur ready formed in nature are comprehended, and the great number of artificial species, often closely related to native minerals, are excluded. It may moreover be said, in objection to these naturalists, that in its wider sense the chemical history of bodies takes into consideration all those characters upon which the so-called natural systems of mineral classification are based. In order to understand clearly the question before us, we must first consider what are the real objects, and what the provinces, respectively, of mineralogy and of chemistry.

Of the three great divisions or kingdoms of nature, the classification of the vegetable gives rise to systematic botany, that of the animal to zoölogy, and that of the mineral to mineralogy, which has for its subject the natural history of all the forms of unorganized matter. The

relations of these to gravity, cohesion, heat, light, electricity, and magnetism belong to the domain of physics, while chemistry is the history of their relations to each other, and of their transformations under the influences of heat, light, and electricity. Chemistry is thus to mineralogy what biology is to organography, and the abstract sciences, physics and chemistry, must precede and form the basis of the concrete science, mineralogy. Many species are chiefly distinguishable by their chemical activities, and hence chemical characters must be greatly depended upon in mineralogical classification.

Chemical change implies disorganization, and all so-called chemical species are inorganic, that is to say, unorganized, and hence really belong to the mineral kingdom. In this extended sense mineralogy takes in not only the few metals, oxides, sulphides, silicates and other salts which are found in nature, but also all those which are the products of the chemist's skill. It embraces not only the few native resins and hydrocarbons, but all the bodies of the carbon series made known to us by the researches of modern chemistry.

The primary object of a natural classification, it must be remembered, is not, like that of an artificial system, to serve the purpose of determining species, or the convenience of the student, but so to arrange bodies in genera, orders, and classes as to satisfy most thoroughly natural affinities. Such a classification, in mineralogy, will be based upon a consideration of all the physical and chemical relations of bodies, and will enable us to see that the various properties of a species are not so many arbitrary signs, but the necessary results of its constitution. It will give for the mineral kingdom what the labors of great naturalists have already nearly attained for the vegetable and animal kingdoms.

Oken saw the necessity of thus enlarging the bounds of mineralogy, and in his Physiophilosophy attempted a mineralogical classification; but it is based upon fanciful and false analogies, with but little reference either to physical or chemical characters, and in the present state of our knowledge is valueless, except as an effort in the right direction, and an attempt to give to mineralogy a natural system. With similar views as to the scope of the science, and with far higher and juster conceptions of its method, Stallo, in his Philosophy of Nature, has touched the questions before us, and has attempted to show the significance of the relations of the metals to cohesion, gravity, light, and electricity, but has gone no further.

In approaching this great problem of classification we have to exam-

ine, first, the physical conditions and relations of each body, considered with reference to gravity, cohesion, light, electricity, and magnetism; secondly, the chemical history of the body, in which are to be considered its nature as elemental or compound, its chemical relations with regard to other bodies, and these chemical relations as modified by physical conditions and forces. The quantitative relation of one mineral (chemical) species to another is its equivalent weight, and the chemical species, until it attains to individuality in the crystal, is essentially quantitative.

It is from all the above data, which would include the whole physical and chemical history of inorganic bodies, that a natural system of mineralogical classification is to be made up. Their application may be illustrated by a few points drawn chiefly from the history of certain natural families.

The variable relation to space of the empirical equivalents of non-gaseous species, or, in other words, the varying equivalent volume obtained by dividing their empirical equivalent weights by the specific gravity, shows that there exist in different species very unlike degrees of condensation. At the same time we are led to the conclusion that the molecular constitution of gems, spars, and ores is such that these bodies must be represented by formulas not less complex, and with equivalent weights far more elevated than those generally assigned to the polycyanides, the alkaloids, and the proximate principles of plants. To similar conclusions conduce also the researches on the specific heat of compounds.

There probably exists between the true equivalent weights of non-gaseous species, and their densities, a relation as simple as that between the equivalent weights of gaseous species and their specific gravities. The gas or vapor of a volatile body constitutes a species distinct from that same body in its liquid or solid state, the chemical formula of the latter being some multiple of the former, and the liquid and solid forms themselves often constituting distinct species of different equivalent weights. In the case of analogous volatile compounds, as the hydrocarbons and their derivatives, the equivalent weights of the liquid or solid species approximate to a constant quantity, so that the density of these species, in the case of homologous or related alcohols, acids, ethers, and glycerides, is subject to no great variation. These non-gaseous species are generated by the chemical union (identification) of a number of volumes or equivalents of the gaseous species, which num-

ber varies inversely as the density of the latter species. It follows from this, that the equivalent weights of the solid and liquid alcohols and fats must be so high as to be a common measure of the vapor-equivalents of all bodies belonging to the above-named series. The empirical formula $C_{114}\ H_{110}\ O_{12}$, which is the lowest one representing the tristearic glyceride, ordinary stearine, is probably far from representing the true equivalent weight of this fat in its liquid or solid state; and if it should hereafter be found that its density corresponds to six times the above formula, it would follow that the equivalent of liquid acetic acid, whose density differs but slightly from that of fused stearine, must have a formula and an equivalent weight about one hundred times that which we deduce from the density of acetic acid vapor. $C_4\ H_4\ O_4$.

Starting from these high equivalent weights of liquid and solid hydrocarbonaceous species, and their correspondingly complex formulas, we are prepared to admit that other orders of mineral species, such as oxides, silicates, carbonates, and sulphides, have formulas and equivalent weights corresponding to their still higher densities, and we proceed to apply to these bodies the laws of substitution, homology, and polymerism, which have so long been recognized in the chemical study of members of the carbon series. The formulas thus deduced for various native silicates and carbon-spars show that these polybasic salts may contain many atoms of different bases, and their frequently complex constitution is thus explained. In the application of the principle of chemical homology we find a ready and natural explanation of the variations, within certain limits, occasionally met with in the composition of certain crystalline silicates, sulphides, etc., from which some have conjectured the existence of a deviation from the law of definite proportions in what is but an expression of that law in a higher form. The principle of polymerism is exemplified in related mineral species, such as meionite and zoisite, dipyre and jadeite, hornblende and pyroxene, calcite and arragonite, opal and quartz, in the zircons of different densities, and in the various forms of titanic acid and of carbon, whose relations become at once intelligible if we adopt for these species high equivalent weights and complex molecules. The hardness of these isomeric or allotropic species and their indifference to chemical agents increase with their condensation, or in other words vary inversely as their empirical equivalent volume, so that we here find a direct relation between chemical and physical properties.

It is in these high chemical equivalents of the species, and in certain

ingenious but arbitrary assumptions of numbers, that is to be found an explanation of the results obtained by Playfair and Joule in comparing the volumes of various solid species with that of ice, which they assume to be represented by H O, instead of a high multiple of this formula. The recent ingenious but fallacious speculations of Dr. Macvicar, who has arbitrarily assumed comparatively high equivalent weights for mineral species, and has then endeavored by conjectures as to the architecture of crystalline molecules to establish relations between his complex formulas and the regular solids of geometry, are curious but unsuccessful attempts to solve some of the problems whose significance I have here endeavored to set forth. I am convinced that no geometrical groupings of atoms, such as are imagined by Macvicar and by Gaudin, can ever give us an insight into the manner in which Nature builds up her units, which is by interpenetration and identification, and not by juxtaposition of the chemical elements.

None of the above points are presented as new, though they are all, I believe, original with myself, and have been from time to time brought forward and maintained, with numerous illustrations, chiefly in the American Journal of Science, since March, 1853, when my Essay on the Theory of Chemical Changes, and on Equivalent Volumes, was there published. I have, however, thought it well to present these views to the Academy in a connected form, as exemplifying my notion of some of the principles which must form the basis of a true mineralogical classification.

Mr. G. W. Hill presented a communication on the Inequalities produced in the Moon's Motion by the secular variation of the position of the Ecliptic.

Five hundred and seventy-seventh Meeting.

January 30, 1867. — STATUTE MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary read a letter from Professor A. C. Kendrick of Rochester, New York, in acknowledgment of his election into the Academy.

The President called the attention of the Academy to the recent decease of M. Cousin of the Foreign Honorary Members.

Nominations for election into the Academy were presented from the Council.

In accordance with the recommendation of the Finance Committee, a special appropriation of five hundred dollars was voted for the engraving of plates to complete the publication of Dr. Storer's Memoir on the Fishes of Massachusetts.

The following gentlemen were elected members of the Academy: —

Dr. Gustavus Hay of Boston, to be Resident Fellow in Class I. Section 1.

Dr. Richard M. Hodges of Boston, to be Resident Fellow in Class II. Section 4.

Mr. Charles S. Peirce of Cambridge, to be Resident Fellow in Class III. Section 1.

Five hundred and seventy-eighth Meeting.

February 12, 1867. — ADJOURNED STATUTE MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary presented letters from Mr. C. S. Peirce and Dr. R. M. Hodges in acknowledgment of their election into the Academy.

The Committee appointed at the Special Meeting, May 8, 1866, to consider and report on the accommodation of the Academy, were discharged.

Professor Lovering reported from the Rumford Committee that the Medals voted to Mr. Alvan Clark were ready for presentation to him.

Five hundred and seventy-ninth Meeting.

February 26, 1867. — SPECIAL MEETING.

The PRESIDENT in the chair.

The President called the attention of the Academy to the recent decease of Dr. Henry Bryant of the Resident Fellows, and of Dr. Alexander Dallas Bache of the Associate Fellows.

Professor Lovering reported from the Rumford Committee

the completion of the Medals awarded to Mr. Alvan Clark, and placed them in the hands of the President. In presenting them to Mr. Clark, the President addressed the Academy as follows: —

GENTLEMEN OF THE ACADEMY: —

Three quarters of a year have passed since, by your unanimous vote, the Rumford premium was awarded to Mr. Alvan Clark. It will be very proper, therefore, now that the gold medal and its silver duplicate are before us, briefly to rehearse the grounds upon which the Rumford Committee recommended, and you decided, to mark by these *insignia* your appreciation of the service which Mr. Clark has rendered to astronomical science in the perfecting of its most important instrument of research, the lens of the refracting telescope.

The two great classes of telescopes, reflectors and refractors, labor under difficulties of construction peculiar to each; and one class or the other has enjoyed the preference of astronomers, according to the degree in which these difficulties have respectively been overcome.

In the refracting telescope the obstacles are, — 1. the want of homogeneousness in the glass; 2. the dispersion of the substance; and 3. imperfection in the figure of the lens. If the first of these difficulties has been reduced to a minimum by a selection of the best materials, then the artist has to contend with the other two. He must give to the four surfaces of his compound achromatic lens such shapes as will produce the maximum of distinctness and the minimum of discoloration in the image of the object seen through it. After all has been accomplished which can be expected from a faithful adherence to general formulæ, the last degree of perfection will depend on the skill of the artist.

Now, just where most artists have supposed that their work was done, our associate has thought that his had only begun. Selecting either a real star, or for greater convenience substituting a fictitious one, he now enters upon an examination of his lens, ring by ring, ascertaining by an ingenious test which *annuli* have too long and which too short *foci*. The lens is then dismounted and retouched at the defective places, is examined and retouched again and again, until his simple test assures him that every portion will converge the rays to the same focus. The long underground tunnel which Mr. Clark has excavated on his grounds, communicating with his workshop, is an original contrivance

for providing a fictitious star, for converting day into night, so that he may examine and repolish at any hour; it also provides a sufficient space filled with homogeneous air, much better adapted for nice observations than the external atmosphere. All this is what is meant by Mr. Clark's *method of local correction*, for which the Rumford premium was awarded. The late Mr. Fitz of New York also used a method of local correction. But he retouched only one surface of his compound lens, and was therefore obliged to leave it with such irregularities as must result from the local working; as it could not be returned to the tool upon which it was originally polished, without rapidly losing all the advantage gained by the local treatment.

Whenever Mr. Clark dismounts his lens and retouches it, he separates the component parts, and applies his local correction to each of the four surfaces. These will tend to fall back to the primitive figure, but, while the elasticity of the tools and the lens together suffice to prevent a very rapid change, under Mr. Clark's skilful and delicate handling he allows for and guards against this by a slight excess of local working. It is, therefore, to this nice, artistic handling that our associate's lenses owe, in no small degree, their pre-eminence.

The justification of the Academy's award is found in the importance and the originality of this method of local correction.

Its importance is assured and measured by the fact that by it a lens of 18 to 20 or even 24 inches' aperture is as manageable under construction now, as 9 to 12 or 15 inch lenses lately were without it. Through this invention and the consummate skill by which it is turned to account, supremacy in this high art, which lingered long in London under the influence of the Dollands, and then deserted its ancient home for Munich, has now confessedly taken up its abode with us in Mr. Clark's unpretending but most efficient establishment at Cambridge.

The originality of the invention will hardly be questioned when it is known that Foucault, as recently as 1858, tried something of the same kind on the single surface of a reflector, with fine results, and then suggested its application to lenses, in honest ignorance that this was what Mr. Clark had been doing for ten years, and in the most delicate and refined way.

In the administration of Count Rumford's trust, the Academy could take notice only of such work as comes within its specific terms, and could adjudge his premium solely in regard to the absolute merit of some particular invention. It could take no account of the difficulties

and disadvantages under which Mr. Clark has struggled on, — without early scientific training, without access to any of the gathered experience which is handed down in optical workshops, without having seen before any, even the commonest, process which he had to execute, with little means of knowing what had already been done, much less how it had been done, without even encouragement until after success achieved made encouragement superfluous, earning by daily toil in one fine art the means and opportunity of developing his genius in an equally refined and to us more important one, — we must allow that where moderate success were highly praiseworthy, the exquisite and unprecedented results which our associate has reached are worthy of double honor.

Nor could the Academy in its award take cognizance of the well-known fact that Mr. Clark's skill and success, not to say genius, in using his telescope are rivalled only by that displayed in perfecting it. Yet this might fairly have been introduced as testimony. For the prompt and brilliant discovery of the before invisible companion of Sirius, and the detection of more than a score of new double stars in the quarter of the heavens which had been most diligently searched for them, especially that most delicate of observations in discovering the companion of υ Herculis, having been made by our associate with his own glasses, and mostly in testing their power, — these should be received as direct witnesses to the importance of his inventions, showing, as an experienced astronomer has remarked, "that objects of great difficulty and delicacy may be detected with *very perfect telescopes* of smaller size, which have escaped the most diligent scrutiny with far larger instruments"; showing also, perhaps, as the same astronomer suggests, in reference to stars which, after withstanding the Pulkova fifteen-inch refractor, Mr. Clark proved to be double with his object-glass of only half that diameter, "that his eye as well as his telescope must possess an extraordinary power of definition."

It is a satisfaction to know that, in an art where genius is so rare, it is sometimes hereditary; that, in this instance, the sons are the compeers of the father; so that, where much has already been secured, still more may be expected. So that now, as the Academy consigns these medals to your hands, Mr. Clark, it gives with them not only the heartiest congratulations, but also the wish and hope of your assembled associates that you may long enjoy the honors you have worthily won; that you may add to them many other triumphs of skill; that you and your

sons with you, and in the course of nature after you, may prolong and enhance the reputation of the establishment at Cambridgeport, so that in future years it may contribute largely, as it now does, to the honor of the country and the advancement of astronomical research.

Mr. Clark responded in the following remarks: —

MR. PRESIDENT AND GENTLEMEN OF THE ACADEMY: —

I know not how I can better express my gratitude for these honors, than by giving some brief account of the manner in which my efforts as a working optician were commenced and have been carried on.

Up to 1844, and when more than forty years of age, I had never witnessed or attempted the grinding of a lens of any description. My elder son, George B. Clark, then a youth of seventeen, during a school vacation, sought amusement in casting and grinding small reflectors for telescopes; and without any thought or design beyond assisting him to find interest and instruction in his pastime, I joined him.

After working, and talking with astronomical friends, and consulting books, until we found that reflectors, even when wrought with utmost skill, were little sought for, I proposed to the youth to try a refractor; but he objected by saying, "The books represent it as a very difficult thing."

Materials were however procured, and the attempt made, with such results as to induce a repetition, and finally another, until it became a settled occupation for us both. Thus it began, as boys' play, and so far as my own spirits and feelings have been affected by it, it has been boys' play all through. So I cannot appeal to your sympathies by any gloomy tale of disappointment or privation.

Hope and courage have been well sustained, and though my circumstances were such that I could not go far, unless purchasers for my lenses could be found, I was fortunately soon able to give them a character which insured their sale.

There exists among the double stars such a variety, in distances and magnitudes, that tests for the excellence of telescopes of different dimensions are always at hand; and through them the value of a glass can be made known, pretty accurately, to a distant correspondent, who has had experience, and is well versed in such matters.

The evidence must, of course, have more weight if the stars selected had never found a place in Struve's or any other catalogues, and were of a character making very sharp defining necessary to exhibit them.

It was in this way the attention of the Rev. W. R. Dawes of England was first called to my seemingly incipient, obscure, and humble labors. I have since sold him five object-glasses, of from seven and a quarter to eight and a quarter inches' aperture, and his published reports upon their qualities have brought orders enough, for a number of years past, to secure for me, in making proficiency, the full benefit of an abundant practice.

The need of sympathy and co-operation from those nearer home, which was sometimes pressing at the outset, was thus, through the influence of Mr. Dawes, greatly alleviated.

I never suffered from the lack of good wishes, but a lack of confidence in my ability to prosecute such an art to successful results prevailed for a time among those who had knowledge of my antecedents.

In April, 1860, an order came from the University of Mississippi for an object-glass of unusual dimensions. In undertaking this it became necessary for me to remove to some more commodious place than the one I had previously occupied. In the same month a site was selected, and dwellings and a workshop erected in the course of the ensuing summer. The material was ordered from Chance & Co. of Birmingham, and preparations made for the work.

This lens was completed in the autumn of 1862, when all communication with Mississippi was cut off. Fortunately they had paid nothing upon it, and I felt at liberty to put it in the market.

George P. Bond manifested much interest in it, visiting me repeatedly while my rough proving tube was in such a position that he could deliberately examine the great nebula in Orion through it; and he placed his opinion of it on record, at the next meeting of the visiting committee, by recommending its purchase for the Cambridge Observatory, and measures were soon on foot for raising the money. When the sum of $ 4,500 had been reached, and my expectations were centred in that direction, I was suddenly and most unexpectedly called upon by a purchaser from Chicago, with a tender of the full price I was to have received from Mississippi. With the assistance of my sons I have since made a mounting for it, and put the instrument up at the Chicago Observatory, where Professor Safford has it in charge.

It was with this glass that my younger son, Alvan G. Clark, discovered the companion of Sirius, on the first occasion of its being looked for, and before the star had been in the field three seconds. Through this business I have been made acquainted with many of the great and

important facts in astronomy, and the laws of light and vision, branches wonderfully calculated to arrest and occupy the attention, in certain stages of mental development, especially when faith in the universality of God's providence goes with them.

The respect and companionship, in a degree I never could have anticipated, of those who dwell by the fountains of knowledge, have cheered me; men whose virtues and accomplishments I can never think to emulate, and whose envy, if they had any, could not descend upon me.

Mr. President, I have said nothing of methods. When first questioned by the Rumford Committee as to what was original in my mode of working, I proposed that they should visit my shop, where I could show and explain to them the course pursued, and they might judge for themselves of the value or originality of any part of it. They have done so; and I accept their decision, trusting the egotism displayed in this little history of achievements may be excused.

You will not fail to perceive, that, after so many years of hopeful, cheerful, and patient toil, mingled with no ordinary share of painstaking, a high appreciation on the part of the recipient must follow this award, as naturally as light comes with the rising of the sun.

Five hundred and eightieth Meeting.

March 12, 1867. — Adjourned Statute Meeting.

The President in the chair.

The President called the attention of the Academy to the necessity of some action for the accommodation of the Academy, and proposed that a committee be appointed to consider this subject.

On the motion of Professor Rogers, it was voted, that a committee of three be appointed, and on the nomination of the President, Colonel Lyman, Mr. C. M. Warren, and Professor C. W. Eliot were chosen.

On the motion of Dr. Clark, this committee were instructed to inquire concerning the co-operation of other societies in providing a building for their common accommodation.

The following paper was presented.

On an Improvement in Boole's Calculus of Logic. By C. S. Peirce.

The principal use of Boole's Calculus of Logic lies in its application to problems concerning probability. It consists, essentially, in a system of signs to denote the logical relations of classes. The data of any problem may be expressed by means of these signs, if the letters of the alphabet are allowed to stand for the classes themselves. From such expressions, by means of certain rules for transformation, expressions can be obtained for the classes (of events or things) whose frequency is sought in terms of those whose frequency is known. Lastly, if certain relations are known between the logical relations and arithmetical operations, these expressions for events can be converted into expressions for their probability.

It is proposed, first, to exhibit Boole's system in a modified form, and second, to examine the difference between this form and that given by Boole himself.

Let the letters of the alphabet denote classes whether of things or of occurrences. It is obvious that an event may either be singular, as "this sunrise," or general, as "all sunrises." Let the sign of equality with a comma beneath it express numerical identity. Thus $a \underset{,}{=} b$ is to mean that a and b denote the same class, — the same collection of individuals.

Let $a \underset{,}{+} b$ denote all the individuals contained under a and b together. The operation here performed will differ from arithmetical addition in two respects: 1st, that it has reference to identity, not to equality; and 2d, that what is common to a and b is not taken into account twice over, as it would be in arithmetic. The first of these differences, however, amounts to nothing, inasmuch as the sign of identity would indicate the distinction in which it is founded; and therefore we may say that

(1.) If No a is b $\quad a \underset{,}{+} b \underset{,}{=} a + b$

It is plain that

(2.) $$a \underset{,}{+} a \underset{,}{=} a$$

and also, that the process denoted by $\underset{,}{+}$, and which I shall call the process of *logical addition*, is both commutative and associative. That is to say

(3.) $$a \underset{,}{+} b \underset{,}{=} b \underset{,}{+} a$$

and

(4.) $$(a +_{,} b) +_{,} c =_{,} a +_{,} (b +_{,} c).$$

Let $a\,,b$ denote the individuals contained at once under the classes a and b; those of which a and b are the common species. If a and b were independent events, $a\,,b$ would denote the event whose probability is the product of the probabilities of each. On the strength of this analogy, (to speak of no other,) the operation indicated by the comma may be called logical multiplication. It is plain that

(5.) $$a\,,a =_{,} a.$$

Logical multiplication is evidently a commutative and associative process. That is,

(6.) $$a\,,b =_{,} b\,,a$$

(7.) $$(a\,,b)\,,c = a\,,(b\,,c).$$

Logical addition and logical multiplication are doubly distributive, so that

(8.) $$(a +_{,} b)\,,c =_{,} a\,,c +_{,} b\,,c$$

and

(9.) $$a\,,b +_{,} c =_{,} (a +_{,} c)\,,(b +_{,} c).$$

Proof. Let $a =_{,} a' + x + y + o$

$$b =_{,} b' + x + z + o$$

$$c =_{,} c' + y + z + o$$

where any of these letters may vanish. These formulæ comprehend every possible relation of a, b and c; and it follows from them, that

$$a +_{,} b =_{,} a' + b' + x + y + z + o \qquad (a +_{,} b)\,,c =_{,} y + z + o.$$

But

$$a\,,c =_{,} y + o \qquad b\,,c =_{,} z + o \qquad a\,,c +_{,} b\,,c =_{,} y + z + o \qquad \therefore (8).$$

So

$$a\,,b =_{,} x + o \qquad a\,,b +_{,} c =_{,} c' + x + y + z + o.$$

But

$$(a +_{,} c) = a' + c' + x + y + z + o \qquad (b +_{,} c) =_{,} b' + c' + x + y + z + o$$

$$(a +_{,} c)\,,(b +_{,} c) =_{,} c' + x + y + z + o \qquad \therefore (9).$$

Let $-_{,}$ be the sign of logical subtraction; so defined that

(10.) If $b +_{,} x =_{,} a \qquad x =_{,} a -_{,} b.$

Here it will be observed that x is not completely determinate. It may vary from a to a with b taken away. This minimum may be denoted by $a - b$. It is also to be observed that if the sphere of b reaches at all beyond a, the expression $a -_{,} b$ is uninterpretable. If then we denote the contradictory negative of a class by the letter which denotes the class itself, with a line above it,* if we denote by v a wholly indeterminate class, and if we allow $[0 -_{,} 1]$ to be a wholly uninterpretable symbol, we have

(11.) $$a -_{,} b =_{,} v\,,a\,,b + a\,,\bar{b} + [0 -_{,} 1]\,,\bar{a}\,,b$$

which is uninterpretable unless

$$\bar{a}\,,b =_{,} 0.$$

If we define zero by the following identities, in which x may be any class whatever,

(12.) $$0 =_{,} x -_{,} x =_{,} x - x$$

then, *zero* denotes the class which does not go beyond any class, that is *nothing* or nonentity.

Let $a\,;b$ be read a logically divided by b, and be defined by the condition that

(13.) If $b\,,x =_{,} a \qquad x =_{,} a\,;b$

x is not fully determined by this condition. It will vary from a to $a + \bar{b}$ and will be uninterpretable if a is not wholly contained under b. Hence, allowing $[1\,;0]$ to be some uninterpretable symbol,

(14.) $$a\,;b =_{,} a\,,b + v\,,\bar{a}\,,\bar{b} + [1\,;0]\;a\,,\bar{b}$$

which is uninterpretable unless

$$a\,,\bar{b} =_{,} 0.$$

Unity may be defined by the following identities in which x may be any class whatever.

(15.) $$1 =_{,} x\,;x =_{,} x:x.$$

Then *unity* denotes the class of which any class is a part; that is, *what is* or *ens*.

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* So that, for example, $\bar{a}$ denotes not-a.

It is plain that if for the moment we allow $a : b$ to denote the maximum value of $a ; b$, then

(16.) $$\bar{x} =_{,} 1 - x =_{,} 0 : x.$$

So that

(17.) $$x \,, (1 - x) =_{,} 0 \qquad x +_{,} 0 : x =_{,} 1.$$

The rules for the transformation of expressions involving logical subtraction and division would be very complicated. The following method is, therefore, resorted to.

It is plain that any operations consisting solely of logical addition and multiplication, being performed upon interpretable symbols, can result in nothing uninterpretable. Hence, if $\varphi + \times\, x$ signifies such an operation performed upon symbols of which x is one, we have

$$\varphi + \times\, x =_{,} a \,, x + b \,, (1 - x)$$

where a and b are interpretable.

It is plain, also, that all four operations being performed in any way upon any symbols, will, in general, give a result of which one term is interpretable and another not; although either of these terms may disappear. We have then

$$\varphi x =_{,} i \,, x + j \,, (1 - x).$$

We have seen that if either of these coefficients i and j is uninterpretable, the other factor of the same term is equal to nothing, or else the whole expression is uninterpretable. But

$$\varphi\ (1) =_{,} i \text{ and } \varphi\ (0) =_{,} j.$$

Hence

(18.) $$\varphi x =_{,} \varphi\ (1) \,, x + \varphi\ (0) \,, (1 - x)$$

$$\varphi\ (x \text{ and } y) =_{,} \varphi\ (1 \text{ and } 1) \,, x \,, y + \varphi\ (1 \text{ and } 0) \,, x, \bar{y} + \varphi\ (0 \text{ and } 1) \,, \bar{x} \,, y + \varphi\ (0 \text{ and } 0) \,, \bar{x} \,, \bar{y}.$$

(18′.) $$\varphi x =_{,} (\varphi\ (1) +_{,} \bar{x}) \,, (\varphi\ (0) +_{,} x)$$

$$\varphi\ (x \text{ and } y) =_{,} (\varphi\ (1 \text{ and } 1) +_{,} \bar{x} +_{,} \bar{y}) \,, (\varphi\ (1 \text{ and } 0) +_{,} \bar{x} +_{,} y) \,, (\varphi\ (0 \text{ and } 1) +_{,} x +_{,} \bar{y}) \,, (\varphi\ (0 \text{ and } 0) +_{,} x +_{,} y).$$

Developing by (18) $x \overline{,}\, y$, we have,

$$x \overline{,}\, y =_{,} (1 \overline{,}\, 1) \,, x \,, y + (1 \overline{,}\, 0) \,, x \,, \bar{y} + (0 \overline{,}\, 1) \,, \bar{x} \,, y + (0 \overline{,}\, 0) \,, \bar{x} \,, \bar{y}.$$

So that, by (11),

(19.) $$(1 \overline{,}\, 1) =_{,} v \qquad 1 \overline{,}\, 0 =_{,} 1 \qquad 0 \overline{,}\, 1 =_{,} [0 \overline{,}\, 1] \qquad 0 \overline{,}\, 0 =_{,} 0.$$

Developing $x\,;y$ in the same way, we have*

$$x\,;y =_{,} 1\,;1\,,x\,,y + 1\,;0\,,x\,,\bar{y} + 0\,;1\,,\bar{x}\,,y + 0\,;0\,,\bar{x}\,,\bar{y}.$$

So that, by (14),

(20.) $1\,;1 =_{,} 1 \qquad 1\,;0 =_{,} [1\,;0] \qquad 0\,;1 =_{,} 0 \qquad 0\,;0 =_{,} v.$

Boole gives (20), but not (19).

In solving identities we must remember that

(21.) $$(a +_{,} b) - b =_{,} a$$

(22.) $$(a -_{,} b) +_{,} b =_{,} a.$$

From $a -_{,} b$ the value of b cannot be obtained.

(23.) $$(a\,,b) \div b =_{,} a$$

(24.) $$a\,;b\,,b =_{,} a.$$

From $a\,;b$ the value of b cannot be determined.

Given the identity $\varphi\, x =_{,} 0.$

Required to eliminate x.

$$\varphi\,(1) =_{,} x\,,\varphi\,(1) + (1 - x)\,,\varphi\,(1)$$

$$\varphi\,(0) =_{,} x\,,\varphi\,(0) + (1 - x)\,,\varphi\,(0).$$

Logically multiplying these identities, we get

$$\varphi\,(1)\,,\varphi\,(0) =_{,} x\,,\varphi\,(1)\,,\varphi\,(0) + (1 - x)\,,\varphi\,(1)\,,\varphi\,(0).$$

For two terms disappear because of (17).

But we have, by (18),

$$\varphi\,(1)\,,x + \varphi\,(0)\,,(1 - x) =_{,} \varphi\, x =_{,} 0.$$

Multiplying logically by x we get

$$\varphi\,(1)\,,x =_{,} 0$$

and by $(1 - x)$ we get

$$\varphi\,(0)\,,(1 - x) =_{,} 0.$$

Substituting these values above, we have

(25.) $$\varphi\,(1)\,,\varphi\,(0) =_{,} 0 \text{ when } \varphi\, x =_{,} 0.$$

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* $a\,;b\,,c$ must always be taken as $(a\,;b)\,,c$, not as $a\,;(b\,,c)$.

Given $$\varphi\, x \mathrel{=_{,}} 1.$$

Required to eliminate x.

Let $$\varphi' x \mathrel{=_{,}} 1 - \varphi\, x \mathrel{=_{,}} 0$$

$$\varphi'(1)\,,\,\varphi'(0) \mathrel{=_{,}} (1 - \varphi(1))\,,\,(1 - \varphi(0)) \mathrel{=_{,}} 0$$

$$1 - (1 - \varphi(1))\,,\,(1 - \varphi(0)) \mathrel{=_{,}} 1.$$

Now, developing as in (18), only in reference to $\varphi(1)$ and $\varphi(0)$ instead of to x and y,

$$1 - (1 - \varphi(1))\,,\,(1 - \varphi(0)) \mathrel{=_{,}} \varphi(1)\,,\,\varphi(0) + \varphi(1)\,,\,(1 - \varphi(0)) + \varphi(0)\,,\,(1 - \varphi(1)).$$

But by (18) we have also,

$$\varphi(1) +_{,} \varphi(0) \mathrel{=_{,}} \varphi(1)\,,\,\varphi(0) + \varphi(1)\,,\,(1 - \varphi(0)) + \varphi(0)\,,\,(1 - \varphi(1)).$$

So that

(26.) $$\varphi(1) +_{,} \varphi(0) \mathrel{=_{,}} 1 \text{ when } \varphi\, x \mathrel{=_{,}} 1.$$

Boole gives (25), but not (26).

We pass now from the consideration of *identities* to that of *equations*.

Let every expression for a class have a second meaning, which is its meaning in an equation. Namely, let it denote the proportion of individuals of that class to be found among all the individuals examined in the long run.

Then we have

(27.) $$\text{If } a \mathrel{=_{,}} b \qquad a = b$$

(28.) $$a + b = (a +_{,} b) + (a\,,\,b).$$

Let b_a denote the frequency of b's among the a's. Then considered as a class, if a and b are events b_a denotes the fact that if a happens b happens.

(29.) $$a\, b_a = a\,,\,b.$$

It will be convenient to set down some obvious and fundamental properties of the function b_a.

(30.) $$a\, b_a = b\, a_b$$

(31.) $$\varphi\,(b_a \text{ and } c_a) = (\varphi\,(b \text{ and } c))_a$$

(32.) $$(1 - b)_a = 1 - b_a$$

(33.) $$b_{\mathrm{a}} = \frac{b}{a} + b_{(1-\mathrm{a})} \left(1 - \frac{1}{a}\right)$$

(34.) $$a_{\mathrm{b}} = 1 - \frac{1-a}{b}\, b_{(1-\mathrm{a})}$$

(35.) $$(\varphi a)_{\mathrm{a}} = (\varphi\,(1))_{\mathrm{a}}.$$

The application of the system to probabilities may best be exhibited in a few simple examples, some of which I shall select from Boole's work, in order that the solutions here given may be compared with his.

Example 1. Given the proportion of days upon which it hails, and the proportion of days upon which it thunders. Required the proportion of days upon which it does both.

Let $1 \underset{,}{=}$ days,

$p \underset{,}{=}$ days when it hails,

$q \underset{,}{=}$ days when it thunders,

$r \underset{,}{=}$ days when it hails and thunders.

$$p \,,\, q \underset{,}{=} r$$

Then by (29), $$r \underset{,}{=} p \,,\, q = p\, q_{\mathrm{p}} = q\, p_{\mathrm{q}}.$$

Answer. The required proportion is an unknown fraction of the least of the two proportions given.

By p might have been denoted the probability of the major, and by q that of the minor premise of a hypothetical syllogism of the following form: —

If a noise is heard, an explosion always takes place;
If a match is applied to a barrel of gunpowder, a noise is heard;
∴ *If a match is applied to a barrel of gunpowder, an explosion always takes place.*

In this case, the value given for r would have represented the probability of the conclusion. Now Boole (p. 284) solves this problem by his unmodified method, and obtains the following answer: —

$$r = p\, q + a\,(1 - q)$$

where a is an arbitrary constant. Here, if $q = 1$ and $p = 0$, $r = 0$. That is, his answer implies that if the major premise be false and the minor be true, the conclusion must be false. That this is not really so

is shown by the above example. Boole (p. 286) is forced to the conclusion that "propositions which, when true, are equivalent, are not necessarily equivalent when regarded only as probable." This is absurd, because probability belongs to the events denoted, and not to forms of expression. The probability of an event is not altered by translation from one language to another.

Boole, in fact, puts the problem into equations wrongly (an error which it is the chief purpose of a calculus of logic to prevent), and proceeds as if the problem were as follows: —

It being known what would be the probability of Y, if X were to happen, and what would be the probability of Z, if Y were to happen; what would be the probability of Z, if X were to happen?

But even this problem has been wrongly solved by him. For, according to his solution, where

$$p = Y_{\mathrm{X}} \qquad q = Z_{\mathrm{Y}} \qquad r = Z_{\mathrm{X}},$$

r must be at least as large as the product of p and q. But if X be the event that a certain man is a negro, Y the event that he is born in Massachusetts, and Z the event that he is a white man, then neither p nor q is *zero*, and yet r vanishes.

This problem may be rightly solved as follows: —

$$\text{Let } p' \mathrel{\underset{,}{=}} Y_{\mathrm{p}} \mathrel{\underset{,}{=}} X, Y$$

$$q' \mathrel{\underset{,}{=}} Z_{\mathrm{q}} \mathrel{\underset{,}{=}} X, Z$$

$$r' \mathrel{\underset{,}{=}} Z_{\mathrm{r}} \mathrel{\underset{,}{=}} X, Z.$$

$$\text{Then, } r' \mathrel{\underset{,}{=}} p', q'; p' \mathrel{\underset{,}{=}} p', q'; q'.$$

Developing these expressions by (18) we have

$$\begin{aligned} r' &\mathrel{\underset{,}{=}} p', q' + r'_{\mathrm{p'}, \bar{\mathrm{q}}'} (p', \bar{q}') + r'_{\bar{\mathrm{p}}', \bar{\mathrm{q}}'} (\bar{p}', \bar{q}') \\ &\mathrel{\underset{,}{=}} p', q' + r'_{\bar{\mathrm{p}}', \mathrm{q}'} (\bar{p}', q') + r'_{\bar{\mathrm{p}}', \bar{\mathrm{q}}'} (p', q'). \end{aligned}$$

The comparison of these two identities shows that

$$r' \mathrel{\underset{,}{=}} p', q' + r'_{\bar{\mathrm{p}}', \bar{\mathrm{q}}'} (\bar{p}', \bar{q}').$$

$$\text{Let } V \mathrel{\underset{,}{=}} r'_{\bar{\mathrm{p}}', \bar{\mathrm{q}}'} \mathrel{\underset{,}{=}} \frac{x, \bar{y}, z}{\bar{x}, y, \bar{z} + \bar{y}}$$

Now
$$p', q' \mathrel{\underset{,}{=}} p' - p', \bar{q}' \mathrel{\underset{,}{=}} q' - q', \bar{p}'$$
$$\bar{p}', \bar{q}' \mathrel{\underset{,}{=}} \bar{q}' - p', \bar{q}' \mathrel{\underset{,}{=}} \bar{p}' - q', \bar{p}'$$

And
$$p', \bar{q}' \mathrel{\underset{,}{=}} p' - p'_{q'} q' \mathrel{\underset{,}{=}} \bar{q}' - \bar{q}'_{\bar{p}'} \bar{p}'$$
$$\bar{p}', q' \mathrel{\underset{,}{=}} q' - q'_{p'} p' \mathrel{\underset{,}{=}} \bar{p}' - \bar{p}'_{\bar{q}'} \bar{q}'$$

Then let
$$A \mathrel{\underset{,}{=}} p'_{q'} \mathrel{\underset{,}{=}} \frac{x, y, z}{y, z}$$
$$B \mathrel{\underset{,}{=}} \bar{q}'_{\bar{p}'} \mathrel{\underset{,}{=}} \frac{\bar{x}, y, \bar{z} + \bar{x}, \bar{y}, z + x, \bar{y}, z + \bar{x}, \bar{y}, \bar{z}}{1 - x, y}$$
$$C \mathrel{\underset{,}{=}} \bar{p}'_{\bar{q}'} \mathrel{\underset{,}{=}} \frac{\bar{x}, y, \bar{z} + \bar{x}, \bar{y}, z + x, \bar{y}, z + \bar{x}, \bar{y}, \bar{z}}{1 - y, z}$$
$$D \mathrel{\underset{,}{=}} q'_{p'} \mathrel{\underset{,}{=}} \frac{x, y, z}{x, y}$$

And we have
$$r = \frac{Y}{Z} p + V\left(\frac{1}{Z} - q\right) - (1 + V)\left(\frac{Y}{Z} p - Aq\right)$$
$$= \frac{Y}{Z} p + V\left(\frac{1}{Z} - q\right) - (1 + V)\left(\frac{1}{Z} - q - B\left(\frac{1 - Yp}{Z}\right)\right)$$
$$= q + V\left(\frac{1 - Yp}{Z}\right) - (1 + V)\left(\frac{1 - Yp}{Z} - C\left(\frac{1}{Z} - q\right)\right)$$
$$= q + V\left(\frac{1 - Yp}{Z}\right) - (1 + V)\left(q - D\,\frac{Y}{Z}\,p\right)$$

Ex. 2. (See Boole, p. 276.) Given r and q; to find p.

$$p \mathrel{\underset{,}{=}} r ; q \mathrel{\underset{,}{=}} r + v, (1 - q) \quad \text{because } p \text{ is interpretable.}$$

Ans. The required proportion lies somewhere between the proportion of days upon which it both hails and thunders, and that added to one minus the proportion of days when it thunders.

Ex. 3. (See Boole, p. 279.) Given, out of the number of questions put to two witnesses, and answered by *yes* or *no*, the proportion that each answers truly, and the proportion of those their answers to which disagree. Required, out of those wherein they agree, the proportion they answer truly and the proportion they answer falsely.

Let $1 \underset{,}{=}$ the questions put to both witnesses,

$p \underset{,}{=}$ those which the first answers truly,

$q \underset{,}{=}$ those which the second answers truly,

$r \underset{,}{=}$ those wherein they disagree,

$w \underset{,}{=}$ those which both answer truly,

$w' \underset{,}{=}$ those which both answer falsely.

$$w \underset{,}{=} p\,,q \qquad w' \underset{,}{=} \bar{p}\,,\bar{q} \qquad r \underset{,}{=} p \underset{,}{+} q - w \underset{,}{=} \bar{p} \underset{,}{+} \bar{q} - w'.$$

Now by (28.)

$$p \underset{,}{+} q = p + q - w \qquad \bar{p} \underset{,}{+} \bar{q} = p - p + 1 - q - w'.$$

Substituting and transposing,

$$2\,w = p + q - r \qquad 2\,w' = 2 - p - q - r.$$

$$\text{Now } w_{1-r} = \frac{w\,,(1-r)}{1-r} \qquad \text{but } w\,,(1-r) \underset{,}{=} w.$$

$$w'_{1-r} = \frac{w',(1-r)}{1-r} \qquad \text{but } w',(1-r) = w'$$

$$\therefore\ w_{(1-r)} = \frac{p+q-r}{2\,(1-r)} \qquad w'_{(1-r)} = \frac{2-p-q-r}{2\,(1-r)}.$$

The differences of Boole's system, as given by himself, from the modification of it given here, are three.

1st. Boole does not make use of the operations here termed logical addition and subtraction. The advantages obtained by the introduction of them are three, viz. they give unity to the system; they greatly abbreviate the labor of working with it; and they enable us to express *particular* propositions. This last point requires illustration. Let i be a class only determined to be such that only some one individual of the class a comes under it. Then $a \underset{,}{-} i\,,a$ is the expression for some a. Boole cannot properly express some a.

2d. Boole uses the ordinary sign of multiplication for logical multiplication. This debars him from converting every logical identity into an equality of probabilities. Before the transformation can be made the equation has to be brought into a particular form, and much labor is wasted in bringing it to that form.

3d. Boole has no such function as a_b. This involves him in two

difficulties. When the probability of such a function is required, he can only obtain it by a departure from the strictness of his system. And on account of the absence of that symbol, he is led to declare that, without adopting the principle that simple, unconditioned events whose probabilities are given are independent, a calculus of logic applicable to probabilities would be impossible.

The question as to the adoption of this principle is certainly not one of words merely. The manner in which it is answered, however, partly determines the sense in which the term "probability" is taken.

In the propriety of language, the probability of a fact either is, or solely depends upon, the strength of the argument in its favor, supposing all relevant relations of all known facts to constitute that argument. Now, the strength of an argument is only the frequency with which *such* an argument will yield a true conclusion when its premises are true. Hence probability depends solely upon the relative frequency of a specific event (namely, that a certain kind of argument yields a true conclusion from true premises) to a generic event (namely, that that kind of argument occurs with true premises). Thus, when an ordinary man says that it is highly probable that it will rain, he has reference to certain indications of rain, — that is, to a certain kind of argument that it will rain, — and means to say that there is an argument that it will rain, which is of a kind of which but a small proportion fail. "Probability," in the untechnical sense, is therefore a vague word, inasmuch as it does not indicate what one, of the numerous subordinated and co-ordinated genera to which every argument belongs, is the one the relative frequency of the truth of which is expressed. It is usually the case, that there is a tacit understanding upon this point, based perhaps on the notion of an *infima species* of argument. But an *infima species* is a mere fiction in logic. And very often the reference is to a very wide genus.

The sense in which the term should be made a technical one is that which will best subserve the purposes of the calculus in question. Now, the only possible use of a calculation of a probability is security in the long run. But there can be no question that an insurance company, for example, which assumed that events were independent without any reason to think that they really were so, would be subjected to great hazard. Suppose, says Mr. Venn, that an insurance company knew that nine tenths of the Englishmen who go to Madeira die, and that nine tenths of the consumptives who go there get well.

How should they treat a consumptive Englishman? Mr. Venn has made an error in answering the question, but the illustration puts in a clear light the advantage of ceasing to speak of probability, and of speaking only of the relative frequency of this event to that.*

Five hundred and eighty-first Meeting.

April 9, 1867. — MONTHLY MEETING.

The PRESIDENT in the chair.

The following paper was presented.

On the Natural Classification of Arguments. By C. S. PEIRCE.

PART I. § 1. *Essential Parts of an Argument.*

In this paper, the term "argument" will denote a body of premises considered as such. The term "premise" will refer exclusively to something laid down, (whether in any enduring and communicable form of expression, or only in some imagined sign,) and not to anything only *virtually* contained in what is said or thought, and also exclusively to that part of what is laid down which is (or is supposed to be) relevant to the conclusion.

Every inference involves the judgment that, if *such* propositions as the premises are are true, then a proposition related to them, as the conclusion is, must be, or is likely to be, true. The principle implied in this judgment, respecting a genus of argument, is termed the *leading principle* of the argument.

A *valid* argument is one whose leading principle is true.

In order that an argument should determine the necessary or probable truth of its conclusion, both the premises and leading principle must be true.

§ 2. *Relations between the Premises and Leading Principle.*

The leading principle contains, by definition, whatever is considered requisite besides the premises to determine the necessary or probable truth of the conclusion. And as it does not contain in itself the subsumption of anything under it, each premise must, in fact, be equivalent to a subsumption under the leading principle.

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* See a notice, Venn's *Logic of Chance*, in the North American Review for July, 1867.

The leading principle can contain nothing irrelevant or superfluous.

No fact, not superfluous, can be omitted from the premises without being thereby added to the leading principle, and nothing can be eliminated from the leading principle except by being expressed in the premises. Matter may thus be transferred from the premises to the leading principle, and *vice versa.*

There is no argument without premises, nor is there any without a leading principle.

It can be shown that there are arguments no part of whose leading principle can be transferred to the premises, and that every argument can be reduced to such an argument by addition to its premises. For, let the premises of any argument be denoted by P, the conclusion by C, and the leading principle by L. Then, if the whole of the leading principle be expressed as a premise, the argument will become

$$L \text{ and } P$$
$$\therefore C.$$

But this new argument must also have its leading principle, which may be denoted by L'. Now, as L and P (supposing them to be true) contain all that is requisite to determine the probable or necessary truth of C, they contain L'. Thus L' must be contained in the leading principle, whether expressed in the premise or not. Hence every argument has, as portion of its leading principle, a certain principle which cannot be eliminated from its leading principle. Such a principle may be termed a *logical principle.*

An argument whose leading principle contains nothing which can be eliminated is termed a *complete*, in opposition to an *incomplete*, *rhetorical*, or *enthymematic* argument.*

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* Neither of these terms is quite satisfactory. Enthymeme is usually defined as a syllogism with a premise suppressed. This seems to determine the same sphere as the definition I have given; but the doctrine of a suppressed premise is objectionable. The sense of a premise which is said to be suppressed is either conveyed in some way, or it is not. If it is, the premise is not suppressed in any sense which concerns the logician; if it is not, it ceases to be a premise altogether. What I mean by the distinction is this. He who is convinced that Sortes is mortal because he is a man (the latter belief not only being the cause of the former, but also being felt to be so) necessarily says to himself that all *such* arguments are valid. This genus of argument is either clearly or obscurely recognized. In the former case, the judgment amounts to another premise, because the proposition (for example), "All reasoning from humanity to mortality is certain," only says in other words

Since it can never be requisite that a fact stated should also be implied in order to justify a conclusion, every *logical principle* considered as a proposition will be found to be quite empty. Considered as regulating the procedure of inference, it is determinate; but considered as expressing truth, it is nothing. It is on this account that that method of investigating logic which works upon syllogistic forms is preferable to that other, which is too often confounded with it, which undertakes to enunciate logical principles.

§ 4. *Decomposition of Argument.*

Since a statement is not an argument for itself, no fact concluded can be stated in any one premise. Thus it is no argument to say All A is B; *ergo* Some A is B.

If one fact has such a relation to another that, if the former is true, the latter is necessarily or probably true, this relation constitutes a determinate fact; and therefore, since the leading principle of a complete argument involves no matter of fact, every complete argument has at least two premises.

Every conclusion may be regarded as a statement substituted for either of its premises, the substitution being justified by the other premises. Nothing is relevant to the other premises, except what is requisite to justify this substitution. Either, therefore, these other premises will by themselves yield a conclusion which, taken as a premise along with the first premise, justifies the final conclusion; or else some part of them, taken with the first premise, will yield a conclusion

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that every man is mortal. But if the judgment amounts merely to this, that the argument in question belongs to some genus all under which are valid, then in one sense it does, and in another it does not, contain a premise. It does in this sense, that by an act of attention such a proposition may be shown to have been virtually involved in it; it does not in this sense, that the person making the judgment did not *actually* understand this premise to be contained in it. This I express by saying that this proposition is contained in the leading principle, but is not *laid down*. This manner of stating the matter frees us at once from all psychological perplexities; and at the same time we lose nothing, since all that we know of thought is but a reflection of what we know of its expression.

These vague arguments are just such as alone are suitable to oratory or popular discourse, and they are appropriate to no other; and this fact justifies the appellation, "rhetorical argument." There is also authority for this use of the term. "Complete" and "incomplete" are adjectives which I have preferred to "perfect" and "imperfect," as being less misleading when applied to argument, although the latter are the best when syllogism is the noun to be limited.

which, taken as a premise along with all the others, will again justify the final conclusion. In either case, it follows that every argument of more than two premises can be resolved into a series of arguments of two premises each. This justifies the distinction of *simple* and *complex* arguments.

§ 5. *Of a General Type of Syllogistic Arguments.*

A valid, complete, simple argument will be designated as a *syllogistic* argument.

Every proposition may, in at least one way, be put into the form,

S is P;

the import of which is, that the objects to which *S* or the *total subject* applies have the characteristics attributed to every object to which *P* or the *total predicate* applies.

Every term has two powers or significations, according as it is subject or predicate. The former, which will here be termed its *breadth*, comprises the objects to which it is applied; while the latter, which will here be termed its *depth*, comprises the characters which are attributed to every one of the objects to which it can be applied. This breadth and depth must not be confounded with logical extension and comprehension, as these terms are usually taken.

Every substitution of one proposition for another must consist in the substitution of term for term. Such substitution can be justified only so far as the first term represents what is represented by the second. Hence the only possible substitutions are —

1st. The substitution for a term fulfilling the function of a subject of another whose breadth is included in that of the former; and

2d. The substitution for a term fulfilling the function of a predicate of another whose depth is included in that of the former.

If, therefore, in either premise a term appears as subject which does not appear in the conclusion as subject, then the other premise must declare that the breadth of that term includes the breadth of the term which replaces it in the conclusion. But this is to declare that every object of the latter term has every character of the former. The eliminated term, therefore, if it does not fulfil the function of predicate in one premise, does so in the other. But if the eliminated term fulfils the function of predicate in one premise, the other premise must declare that its depth includes that of the term which replaces it in the conclusion. Now, this is to declare that every character of

the latter term belongs to every object of the former. Hence, in the other premise, it must fulfil the function of a subject. Hence the general formula of all argument must be

$$M \text{ is } P$$

$$S \text{ is } M$$

$$\therefore S \text{ is } P;$$

which is to be understood in this sense, — that the terms of every syllogistic argument fulfil functions of subject and predicate as here indicated, but not that the argument can be grammatically expressed in this way.

Part II. § 1. *Of Apagogical Forms.*

If C is true when P is, then P is false when C is. Hence it is always possible to substitute for any premise the denial of the conclusion, provided the denial of that premise be at the same time substituted for the conclusion.* Hence, corresponding to every syllogistic argument in the general form,

$$S \text{ is } M; \; M \text{ is } P;$$

$$S \text{ is } P.$$

There are two others: —

It is false that S is P; M is P;
It is false that S is M.

S is M; it is false that S is P;
It is false that M is P.

§ 2. *Of Contradiction.*

The apagogical forms make it necessary to consider in what way propositions deny one another.

If a proposition be put into the general form,

$$S \text{ is } P,$$

its contradictory has, 1st, as its subject, instead of S, "the S now

* This operation will be termed a *contraposition* of the premise and conclusion.

meant"* or "some *S*"; and has, 2d, as its predicate, instead of *P*, that which differs from *P* or "not *P*."

From these relations of contradictories, from the necessities of the logic of apagogically related arguments, therefore, arises the need of the two divisions of propositions into affirmative and negative on the one hand, and into universal and particular on the other. The contradictory of a universal proposition is particular, and the contradictory of an affirmative proposition is negative. Contradiction is a reciprocal relation, and therefore the contradictory of a particular proposition is universal, and that of a negative proposition is affirmative. The contradiction of particular and negative propositions could not be brought under the general formula, were the distinctions of affirmative and negative absolute and not merely relative; but, in fact, not-not-*P* is the same as *P*. And, if it is said that "what is now meant of the part of *S* meant at another time, is *P*," since the part of *S* meant at another time is left to be determined in whatever way the proposition made at another time may determine it, this can only be true if All *S* is *P*. Therefore, if one man says "some *S* is not *P*," and another replies, "some of that same *S* is *P*," this second person, since he allows the first man's some *S*, which has not been defined, to remain undefined, in effect says that All *S* is *P*.

Whether contradictories differ in other respects than these well-known ones is an open question.

§ 3. *Of Barbara.*

Since some *S* means "the part now meant of *S*," a particular proposition is equivalent to a universal proposition with another subject; and in the same way a negative proposition is equivalent to an affirmative proposition with another predicate.

The form, S is P,

therefore, as well as representing propositions in general, particularly represents Universal Affirmative propositions; and thus the general form of syllogism

$$M \text{ is } P; \ S \text{ is } M;$$
$$S \text{ is } P,$$

represents specially the syllogisms of the mood *Barbara*.

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* What *S* is meant being generally undetermined.

§ 4. *Of the First Figure.*

Since, in the general form, *S* may be any subject and *P* any predicate, it is possible to modify Barbara by making the major premise and conclusion negative, or by making the minor premise and conclusion particular, or in both these ways at once. Thus we obtain all the modes of the first figure.

It is also possible to have such arguments as these:—

Some *M* is *P*,

S has all the common characters of *that* part of *M* (whatever that part may be, and therefore of each and every *M*),

∴ *S* is *P*,

and

All not-*M* is *P*,

S is not *M*,

∴ *S* is *P*;

but as the theory of apagogical argument has not obliged us to take account of these peculiar modifications of subject and predicate, these arguments must be considered as belonging to Barbara. In this sense the major premise must always be universal, and the minor affirmative.

Three propositions which are related to one another as though major premise, minor premise, and conclusion of a syllogism of the first figure will be termed respectively *Rule, Case,* and *Result.*

§ 5. *Second and Third Figures.*

Let the first figure be written thus:—

Fig. 1.

Any	**M**	is / is not	**P**
Any / Some	**S**	is	**M**
Any / Some	**S**	is / is not	**P**

Then its two apagogical modifications are the second and third figures.

Fig. 2.				*Fig.* 3.			
Any	**M**	is / is not	**P**	Some / Any	**S**	is not / is	**P**
Some / Any	**S**	is not / is	**P**	Any / Some	**S**	is	**M**
Some / Any	**S**	is not	**M**	Some	**M**	is not / is	**P**

It is customary to enumerate six moods of the third figure instead of four, and the moods Darapti and Felapton appear to be omitted. But a particular proposition is asserted (actually and not merely virtually) by the universal proposition which does not otherwise differ from it; and therefore Darapti is included both under Disamis and Datisi, and Felapton both under Bocardo and Ferison. (De Morgan.)

The second figure, from the assertion of the rule and the denial of the result, infers the denial of the case; the third figure, from the denial of the result and assertion of the case, infers the denial of the rule. Hence we write the moods as follows, by allowing inferences only on the straight lines: —

Fig. 1.

Assertion of Rule,

Assertion of Case;

Assertion of Result.

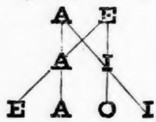


Fig. 2.

Assertion of Rule,

Denial of Result;

Denial of Case.

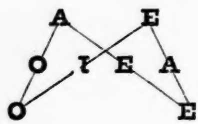
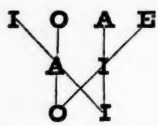


Fig. 3.

Denial of Result,

Assertion of Case;

Denial of Rule.



The symmetry of the system of moods of the three figures is also exhibited in the following table.

Enter at the top the proposition asserting or denying the rule; enter at the side the proposition asserting or denying the case; find in the body of the table the proposition asserting or denying the result. In the body of the table, propositions indicated by italics belong to the first figure, those by black-letter to the second figure, and those by script to the third figure.

	I	A	E	O
E		$\mathfrak{E}$	$\mathfrak{A}$	
A	$\mathscr{I}$	A	E	$\mathscr{O}$
I	$\mathscr{A}$	I	O	$\mathscr{E}$
O		$\mathfrak{O}$	$\mathfrak{I}$	

If, as the denial of the result in the second and third figures, we put the form "Any N is N," we have —

Fig. 2.	*Fig.* 3.
No M is N	Any N is N
Any N is N	Some N is M
∴ No N is M.	∴ Some M is N.

These are the formulæ of the two simple conversions. Neither can be expressed syllogistically except in the figures in which they are here put (or in what is called the fourth figure, which we shall consider hereafter). If, for the denial of the result in the second figure, we put "No not-N is N" (where "not-N" has not as yet been defined) we obtain

All M is N,

No not-N is N;

∴ No not-N is M.

In the same way, if we put "Some N is some-N" (where some-N has not been defined) for the denial of the result in the third figure, we have

Some N is some-N

All N is M

∴ Some M is some-N.

These are the two ways of contraposing the Universal Affirmative.

There are two ostensive reductions of each mood of the second and third figures. I shall distinguish them as the short reduction and the long reduction. The short reduction is effected by converting or contraposing that premise which is not the denial of the result. The long reduction is effected by transposing the premises, contraposing or converting the denial of the result, and contraposing or converting the conclusion. The alteration thus produced in the order of the terms is shown in the following figure: —

		Short Reduction.		*Long Reduction.*	
N	M	M	N	M	Ξ
Ξ	M	Ξ	M	N	M
Ξ	N	Ξ	N	N	Ξ
Σ	Π	Σ	Π	Σ	P
Σ	P	P	Σ	Π	Σ
P	Π	P	Π	Π	P

The names bestowed by Shyreswood, or Petrus Hispanus, upon the moods indicate the possibility of the short reduction in the case of Cesare and Festino of the second figure, and of Datisi and Ferison of the third figure; also the possibility of the long reduction of Camestres of the second figure and of Disamis of the third.

The short reduction of Camestres and Baroco is effected by introducing the term not-P, and defining it as that which S *is* when it is *not* P. Hence for the second premise (Any or some S is not P) we substitute "Any or some S is not-P"; and as the first premise, Any M is P, gives by contraposition Any not-P is not M, the moods

Any M is P,

Any or some S is not P;

∴ Any or some S is not M,

are reduced to

No not-P is M,

Any or some S is not-P;

∴ Any or some S is not M.

The short reduction of Disamis and Bocardo is effected by introducing the term some-S, defining it as that part of S which is or is not P when some S is or is not P. We can therefore substitute for the first premise, Some S is or is not P, All some-S is or is not P; while, for the second premise, All S is M, can be contraposed into "Some M is some-S": and thus the forms

Some S is (*or* is not) P,

Any S is M;

∴ Some M is (*or* is not) P,

are reduced to the following:—

Any some-S is (*or* is not) P,

Some M is some-S;

∴ Some M is (*or* is not) P.

To reduce Cesare, Festino, and Baroco in the long way, it is necessary to introduce the terms not-P and some-S. Not-P is defined as that class to which any M belongs which is not P. Hence for the first premise of Cesare and Festino we can substitute "Any M is not-P." Some-S is defined as that class of S which is (or is not) P, when some S is (or is not) P. Hence for the second premises of Festino and Baroco we can first substitute "Any some-S is (or is not) P"; and then, by contraposition or conversion, we obtain "Any P (or not-P) is not some-S." Then, by the transposition of the premises, we obtain from Cesare, which is

No M is P	Any not-P is not S
Any S is P	Any M is not-P
(∴ No S is M).	∴ Any M is not-S.

And from the conclusion of this reduced form we obtain the conclusion of Cesare by simple conversion. So Festino and its long reduction are

Any *M* is not *P*,	Any not-*P* is not some-*S*,
Some *S* is *P*;	Any *M* is not-*P*;
(∴ Some *S* is not *M*.)	∴ Any *M* is not some-*S*;

and the conclusion of Festino is obtained from that of the reduced form by a substitution which may be made syllogistically thus: —

Any *M* is not some-*S*,
Some *S* is some-*S*;
∴ Some *S* is not *M*.

Baroco and its long reduction are

Any *M* is *P*,	Any *P* is not some-*S*,
Some *S* is not *P*;	Any *M* is *P*;
(∴ Some *S* is not *M*.)	∴ Any *M* is not some-*S*;

and the conclusion of Baroco is obtained from the conclusion of the reduction in the same way as that of Festino.

In order to reduce Datisi, Bocardo, and Ferison in the long way, we must define Some-*S* as that *S* which is *M* when some *S* is *M*, and Not-*P* as that which some (or any) *S* *is* when it is *not* P. Hence for "Some *S* is *M*" we can substitute "Any some-*S* is *M*"; and for "Some (or any) *S* is not *P*," "Some (or any) *S* is not-*P*." "Some *S* is not-*P*" may be converted simply; and "Any *S* is not-*P*" may be contraposed so as to become "Some not-*P* is some-*S*." Then Datisi and its long reduction are

Any *S* is *P*,	Any some-*S* is *M*,
Some *S* is *M*;	Some *P* is some-*S*;
(∴ Some *M* is *P*.)	∴ Some *P* is *M*.

And from the conclusion of the reduction, the conclusion of Datisi is

obtained by simple conversion. Ferison and its long reduction are

Any S is not P,	Any some-S is M,
Some S is M;	Some not-P is some-S';
($\therefore$ Some M is not P.)	$\therefore$ Some not-P is M.

And from the conclusion of the reduction, the conclusion of Ferison may be obtained by a substitution whose possibility is expressed syllogistically thus: —

Any not-P is not P,
Some not-P is M;
$\therefore$ Some M is not P.

Bocardo and its long reduction are

Some S is not P,	Any S is M,
Any S' is M;	Some not-P is S;
($\therefore$ Some M is not P.)	$\therefore$ Some not-P is M.

And the conclusion of Bocardo is obtained from that of its reduction in the same way as the conclusion of Ferison.

The ostensive reduction of the indirect or apagogical figures may be considered as the exhibition of them under the general form of syllogism,

S is M; M is P:
$\therefore S$ is P.

But, in this sense, it is not truly a reduction if the substitutions made in the process are inferences. But although the possibility of the conversions and contrapositions can be expressed syllogistically, yet this can be done only by taking as one of the premises,

"All N is N,"
"Any not-N is not N,"
or "Some N is some-N."

Now, these are properly not premises, for they express no facts; they are merely forms of words without meaning. Hence, as no complete argument has less than two premises, the conversions and contrapositions are not inferences. The only other substitutions which have been made have been of not-P and some-S for their definitions. These also can be put into syllogistic form; but a mere modification of language is not an inference. Hence no inferences have been employed in reducing the arguments of the second and third figures to such forms that they are readily perceived to come under the general form of syllogism.

There is, however, an intention in which these substitutions are inferential. For, although the passage from holding for true a fact expressed in the form "No A is B," to holding its converse, is not an inference, because, these facts being identical, the relation between them is not a fact; yet the passage from one of these forms taken merely as having *some* meaning, but not this or that meaning, to another, since these forms are not identical and their logical relation is a fact, is an inference. This distinction may be expressed by saying that they are not inferences, but substitutions having the *form* of inferences.

Thus the reduction of the second and third figures, considered as mere forms, is inferential; but when we consider only what is meant by any particular argument in an indirect figure, the reduction is a mere change of wording.

The substitutions made use of in the ostensive reductions are shown in the following table. Where

e, denotes simple conversion of E;

i, denotes simple conversion of I;

a_2, contraposition of A into E;

a_3, contraposition A into I;

o_2, the substitution of "Some S is not M" for "Any M is not some-S";

o_3, the substitution of "Some M is not P" for "Some not-P is M";

e'', introduction of not-P by definition;

i'', introduction of some-S by definition.

Reduction of Second Figure.		
Name of Mood.	Short Reduction.	Long Reduction.
Cesare	e	$e'' \; a_2 \; e$
Camestres	$a_2 \; e''$	$e \; e$
Festino	e	$e'' \; i'' \; a_2 \; o_2$
Baroco	$a_2 \; e''$	$i'' \; e \; o_2$

Reduction of Third Figure.		
Name of Mood.	Short Reduction.	Long Reduction.
Disamis	$a_3 \; i''$	$i \; i$
Datisi	i	$i'' \; a_3 \; i$
Bocardo	$a_3 \; i''$	$e'' \; i \; o_3$
Ferison	i	$i'' \; e'' \; a_3 \; o_3$

With the exception of the substitutions i'' and e'', which will be considered hereafter, all those which are used in the reduction of the moods of either oblique figure have the form of inferences in the same figure.

The so-called *reductio per impossibile* is the repetition or inversion of that contraposition of propositions by which the indirect figures have been obtained. Now, contradiction arises from a difference both in quantity and quality; but it is to be observed that, in the contraposition which gives the second figure, a change of the *quality* alone, and in that which gives the third figure a change of the *quantity* alone, of the contraposed propositions, is sufficient. This shows that the two

contrapositions are of essentially different kinds, and that the reductions *per impossibile* of the second and third figures respectively involve the following formal inferences.*

FIGURE 2.

The Result follows from the Case;
∴ The Negative of the Case follows from the Negative of the Result.

FIGURE 3.

The Result follows from the Rule;
∴ The Rule changed in Quantity follows from the Result changed in Quantity.

But these inferences may also be expressed as follows: —

FIGURE 2.

Whatever (S) is M is $\substack{P \\ \text{not } P}$;

∴ Whatever (S) is $\substack{\text{not } P \\ P}$ is not M.

FIGURE 3.

Any $\substack{S \\ \text{some } S}$ is whatever (P or not-P) M is;

∴ Some M is whatever (P or not-P) $\substack{\text{some } S \\ S}$ is.

Now, the limitations in parentheses do not affect the essential nature of the inferences; and omitting them we have,

FIGURE 2.

Any M is $\substack{P \\ \text{not } P}$;

∴ Any $\substack{\text{not } P \\ P}$ is not M.

FIGURE 3.

Any $\substack{S \\ \text{some } S}$ is M;

∴ Some M is $\substack{\text{some } S \\ S}$.

---

* A formal inference is a substitution having the form of an inference.

We have already seen that the former of these is of the form of the second figure, and the latter of the form of the third figure of syllogism.

Hence it appears that no syllogism of an indirect figure can be reduced to the first figure without a substitution which has the form of the very figure from which the syllogism is reduced. In other words, the indirect syllogisms are of an essentially different form from that of the first figure, although in a more general sense they come under that form.

§ 6. *The Theophrastean Moods.*

It is now necessary to consider the five moods of Theophrastus, viz. *Baralipton, Celantes, Dabitis, Fapesmo, Frisesomorum.* Baralipton is included in Dabitis, and Fapesmo in Frisesomorum, in the same way in which Darapti is included in Disamis and Datisi, and Felapton in Bocadro and Ferison. The Theophrastean moods are thus reduced to three, viz.: —

No X is Y,	No X is Y,	Some Y is Z,
All Z is X;	Some Y is Z;	All Z is X;
∴ Any Y is not Z.	∴ Some Z is not X.	∴ Some X is Y.

Suppose we have, 1st, a Rule; 2d, a Case under that rule, which is itself a Rule; and, 3d, a Case under this second rule, which conflicts with the first rule. Then it would be easy to prove that these three propositions must be of the form,

1. No X is Y.
2. All Z is X.
3. Some Y is Z.

These three propositions cannot all be true at once; if, then, any two are asserted, the third must be denied, which is what is done in the three Theophrastean moods.

These moods are resolved into one another by the contraposition of propositions, and therefore should be considered as belonging to different figures.

They can be ostensively reduced to the first Aristotelian figure in two ways; thus,

	Short Reduction.	*Long Reduction.*
$B\ A$	$B\ A$	$B\ \Gamma$
$\Gamma\ B$	$\Gamma\ B$	$A\ B$
$A\ \Gamma$	$\Gamma\ A$	$A\ \Gamma$

The verses of Shyreswood show how Celantes and Dabitis are to be reduced in the short way, and Frisesomorum in the long way. Celantes and its long reduction are as follows:—

Any X is not Y,	Any not-X is not Z,
Any Z is X;	Any Y is not-X;
∴ Any Y is not Z.	∴ Any Y is not Z.

"Any X is not Y," becomes, by conversion, "Any Y is not X." The term "not-X" is then introduced, being defined as that which Y is when it is not X. Then "Z is X" becomes "Any not-X is not Z"; and, the premises being transposed, the reduction is effected.

Dabitis and its long reduction are as follows:—

Any Z is X,	Any some-Z is Y,
Some Y is Z;	Some X is some-Z;
∴ Some X is Y.	∴ Some X is Y.

"Some Y is Z" becomes, by conversion, "Some Z is Y." Then the term "some-Z" is introduced, being defined as that Z which is Y if "some Z is Y." Then "Any Z is X" becomes "Some X is some-Z," and, the premises being transposed, the reduction is effected.

Frisesomorum is,

Some Y is Z,

Any X is not Y;

∴ Some Z is not X.

Let some-Y be that Y which is Z when some Y is Z; and then we have,

Some Y is some-Y,

Any X is not Y;

∴ Some some-Y is not X.

Then let not-X be that which any Y is when some Y is not X, and we have,

Some some-Y is not-X,

which yields by conversion,

Some not-X is some-Y;

and we thus obtain the reduction,

Any some-Y is Z,

Some not-X is some-Y;

∴ Some not-X is Z.

From the conclusion of this reduction, the conclusion of Frisesomorum is justified as follows: —

Some not-X is Z,

Any X is not not-X;

∴ Some Z is not X.

Another mode of effecting the short reduction of Frisesomorum is this: Let not-Y be that which any X is when no X is Y, and we have

Some Y is Z,

Any not-Y is not Y;

∴ Some Z is not not-Y.

Let some-Z be that Z which is not not-Y when some Z is not-Y, and we have,

Any some-Z is not not-Y,

and by conversion,

Any not-Y is not some-Z.

Thus we obtain as the reduced form,

Any not-Y is not some-Z,

Any X is not-Y;

$\therefore$ Any X is some-Z.

From the conclusion of this reduction, we get that of Frisesomorum thus: —

Some some-Z is Z,

Any X is not some-Z;

$\therefore$ Some Z is not X.

In either reduction of Celantes, if we neglect the substitution of terms for their definitions, the substitutions are all of the second syllogistic figure. This of itself shows that Celantes belongs to that figure, and this is confirmed by the fact that it concludes the denial of a Case. In the same way, the reductions of Dabitis involve only substitutions in the third figure, and it concludes the denial of a Rule. Frisesomorum concludes a proposition which is at once the denial of a rule and the denial of a case: its long reduction involves one conversion in the second figure and another in the third, and its short reductions involve conversions in Frisesomorum itself. It therefore belongs to a figure which unites the characters of the second and third, and which may be termed the second-third figure in Theophrastean syllogism.

There are, then, two kinds of syllogism, — the Aristotelian and Theophrastean. In the Aristotelian occur the 1st, 2d, and 3d figures, with four moods of each. In the Theophrastean occur the 2d, 3d, and 2d-3d figures, with one mood of each. The first figure is the fundamental or typical one, and Barbara is the typical mood. There is a strong analogy between the figures of syllogism and the four forms of proposition. A is the fundamental form of proposition, just as the first figure is the fundamental form of syllogism. The second and third figures are derived from the first by the contraposition of propositions, and E and I are derived from A by the contraposition of terms; thus: —

Any S is P.

Any not-P is not S. Some P is some-S.

O combines the modifications of *E* and *I*, just as the 2d-3d figure combines the 2d and 3d. In the second-third figure, only *O* can be concluded, in the third only *I* and *O*, in the second only *E* and *O*, in the first either *A E I O*. Thus *A* is the first figure of proposition, *E* the second, *I* the third, *O* the second-third.*

§ 7. *Mathematical Syllogisms.*

A kind of argument very common in mathematics may be exemplified as follows: —

Every part is less than that of which it is a part,
Boston is a part of the Universe;
∴ Boston is less than the Universe.

This may be reduced to syllogistic form thus: —

Any relation of part to whole is a relation of less to greater,
The relation of Boston to the Universe is a relation of part to whole;
∴ The relation of Boston to the Universe is a relation of less to greater.

If logic is to take account of the peculiarities of such syllogisms, it would be necessary to consider some propositions as having three terms, subject, predicate, and object; and such propositions would be divided into *active* and *passive*. The varieties in them would be endless.

Part III. § 1. *Induction and Hypothesis.*

In the syllogism,

$$\begin{array}{l} \text{Any } M \text{ is } P, \\ \Sigma' S' \text{ is } M; \\ \therefore \Sigma' S' \text{ is } P; \end{array}$$

where $\Sigma' S'$ denotes the sum of all the classes which come under *M*. if the second premise and conclusion are known to be true, the first

* Hypotheticals have not been considered above, the well-known opinion having been adopted that, "If *A*, then *B*," means the same as "Every state of things in which *A* is true is a state of things in which *B* is (or will be) true."

premise is, by enumeration, true. Whence we have, as a valid demonstrative form of inference,

$$\begin{array}{rcl} \Sigma' S' & \text{is} & P, \\ \Sigma' S' & \text{is} & M; \\ \therefore\ M & \text{is} & P. \end{array}$$

This is called perfect induction. It would be better to call it formal induction.

In a similar way, from the syllogism,

$$\begin{array}{lcl} \text{Any } M & \text{is} & \Pi' P', \\ \text{Any } S & \text{is} & M; \\ \therefore \text{Any } S & \text{is} & \Pi' P'; \end{array}$$

where $\Pi' P'$ denotes the conjunction of all the characters of M, if the conclusion and first premise are true, the second premise is true by definition; so that we have the demonstrative form of argument,

$$\begin{array}{lcl} \text{Any } M & \text{is} & \Pi' P', \\ \text{Any } S & \text{is} & \Pi' P'; \\ \therefore \text{Any } S & \text{is} & M. \end{array}$$

This is reasoning from definition, or, as it may be termed, formal hypothesis.

One half of all possible propositions are true, because every proposition has its contradictory. Moreover, for every true particular proposition there is a true universal proposition, and for every true negative proposition there is a true affirmative proposition. This follows from the fact that the universal affirmative is the type of all propositions. Hence of all possible propositions in either of the forms,

$$\Sigma' S' \text{ is } M, \text{ and } M \text{ is } \Pi' P',$$

one half are true. In an untrue proposition of either of these forms, some finite ratio of the S's or P's are not true subjects or predicates. Hence, of all propositions of either of these forms which are partly true, some finite ratio more than one half are wholly true. Hence, if in the above formulæ for formal induction or hypothesis, we substitute

S' for $\Sigma' S'$ and P' for $\Pi' P'$ we obtain formulæ of probable inference. This reasoning gives no *determinate* probability to these modes of inference, but it is necessary to consider that, however weak synthetic inference might have been at first, yet if it had the least positive tendency to produce truth, it would continually become stronger, owing to the establishment of more and more secure premises.

The rules for valid induction and hypothesis deducible from this theory are as follows: —

1. The explaining syllogism, that is to say, the deductive syllogism one of whose premises is inductively or hypothetically inferred from the other and from its conclusion, must be valid.

2. The conclusion is not to be held as absolutely true, but only until it can be shown that, in the case of induction, S' was taken from some narrower class than M, or, in the case of hypothesis, that P' was taken from some higher class than M.

3. From the last rule it follows as a corollary that in the case of induction the subject of the premises must be a sum of subjects, and that in the case of hypothesis the predicate of the premises must be a conjunction of predicates.

4. Also, that this aggregate must be of different objects or qualities and not of mere names.

5. Also, that the only principle upon which the instanced subjects or predicates can be selected is that of belonging to M.*

---

* Positivism, apart from its theory of history and of the relations between the sciences, is distinguished from other doctrines by the manner in which it regards hypotheses. Almost all men think that metaphysical theories are valueless, because metaphysicians differ so much among themselves; but the positivists give another reason, namely, that these theories violate the sole condition of all legitimate hypothesis. This condition is that every good hypothesis must be such as is certainly capable of subsequent verification with the degree of certainty proper to the conclusions of the branch of science to which it belongs. There is, it seems to me, a confusion here between the probability of a hypothesis in itself, and its admissibility into any one of those bodies of doctrine which have received distinct names, or have been admitted into a scheme of the sciences, and which admit only conclusions which have a very high probability indeed. I have here to deal with the rule only so far as it is a general canon of the *legitimacy* of hypotheses, and not so far as it determines their *relevancy* to a particular science; and I shall, therefore, consider only another common statement of it; namely, "that no hypothesis is admissible which is not capable of verification by direct observation." The positivist regards an hypothesis, not as an inference, but as a device for stimulating and

Hence the formulæ are

Induction.

S' S'' S''', &c. are taken at random as M's,

S' S'' S''', &c. are P;

∴ Any M is probably P.

---

directing observation. But I have shown above that certain premises will render an hypothesis probable, so that there is such a thing as legitimate hypothetic inference. It may be replied that such conclusions are not hypotheses, but inductions. That the sense in which I have used "hypothesis" is supported by good usage, I could prove by a hundred authorities. The following is from Kant: "An hypothesis is the holding for true of the judgment of the truth of a reason on account of the sufficiency of its consequents." Mill's definition (Logic, Book III. Ch. XIV. § 4) also nearly coincides with mine. Moreover, an hypothesis in every sense is an inference, because it is adopted for some reason, good or bad, and that reason, in being regarded as such, is regarded as lending the hypothesis some plausibility. The arguments which I term hypothetic are certainly not inductions, for induction is reasoning from particulars to generals, and this does not take place in these cases. The positivist canon for hypotheses is neither sufficient nor necessary. If it is granted that hypotheses are inferred, it will hardly be questioned that the observed facts must follow apodictically from the hypothesis without the aid of subsidiary hypotheses, and that the characters of that which is predicated in the hypothesis, and from which the inference is drawn, must be taken as they occur, and not be picked out in order to make a plausible argument. That the maxim of the positivists is superfluous or worse, is shown, first, by the fact that it is not implied in the proof that hypothetic inference is valid; and next, by the absurdities to which it gives rise when strictly applied to history, which is entirely hypothetical, and is absolutely incapable of verification by direct observation. To this last argument I know of but two answers: first, that this pushes the rule further than was intended, it being considered that history has already been so verified; and second, that the positivist does not pretend to know the world as it absolutely exists, but only the world which appears to him. To the first answer, the rejoinder is that a rule must be pushed to its logical consequences in all cases, until it can be shown that some of these cases differ in some material respect from the others. To the second answer, the rejoinder is double: first, that I mean no more by "is" than the positivist by "appears" in the sense in which he uses it in saying that only what "appears" is known, so that the answer is irrelevant; second, that positivists, like the rest of the world, reject historic testimony sometimes, and in doing so distinguish hypothetically between what is and what in some other sense appears, and yet have no means of verifying the distinction by direct observation.

Another error in reference to hypothesis is, that the antecedent probability of what is testified to cannot affect the probability of the testimony of a good witness. This is as much as to say that probable arguments can neither support nor weaken one another. Mr. Venn goes so far as to maintain the impossibility of a conflict of probabilities. The difficulty is instantly removed by admitting indeterminate probabilities.

Hypothesis.

Any M is, for instance, $P' \; P'' \; P'''$, &c.,

S is $P' \; P'' \; P'''$, &c.;

$\therefore$ S is probably M.

§ 2. *Moods and Figures of Probable Inference.*

It is obvious that the explaining syllogism of an induction or hypothesis may be of any mood or figure.

It would also seem that the conclusion of an induction or hypothesis may be contraposed with one of the premises.

§ 3. *Analogy.*

The formula of analogy is as follows: —

S', S'', and S''' are taken at random from such a class that their characters at random are such as P', P'', P'''.

t is P', P'', and P'''.

S', S'', and S''' are q.

$\therefore$ t is q.

Such an argument is double. It combines the two following: —

1.

S', S'', S''' are taken as being P', P'', P'''.

S', S'', S''' are q.

$\therefore$ (By induction,) P', P'', P''' is q.

t is P', P'', P'''.

$\therefore$ (Deductively,) t is q.

2.

S', S'', S''' are, for instance, P', P'', P'''.

t is P', P'', P'''.

$\therefore$ (By hypothesis,) t has the common characters of S', S'', S'''.

S', S'', S''' are q.

$\therefore$ (Deductively,) t is q.

Owing to its double character, analogy is very strong with only a moderate number of instances.

§ 4. *Formal Relations of the above Forms of Argument.*

If we take an identical proposition as the fact to be explained by induction and hypothesis, we obtain the following formulæ.

By Induction.

S, S', S'' are taken at random as being M,

S, S', S'' have the characters common to S, S', S''.

$\therefore$ Any M has the characters common to S, S', S''.

By Hypothesis.

M is, for instance, P, P', P''.

Whatever is at once P, P', and P'' is P, P', P''.

$\therefore$ Whatever is at once P, P', and P'' is M.

By means of the substitution thus justified, Induction and Hypothesis can be reduced to the general type of syllogism, thus: —

Induction.

S, S', S'' are taken as M,

S, S', S'' are P;

$\therefore$ Any M is P.

Reduction.

S, S', S'' are P;

Almost any M has the common characters of S, S', S'.

$\therefore$ Almost any M is P.

Hypothesis.

M is, for instance, P', P'', P''',

S is P', P'', P''';

$\therefore$ S is M.

Reduction.

Whatever is, at once, P', P'', P''' is like M,

S is P', P'', P''';

$\therefore$ S is like M.

Induction may, therefore, be defined as argument which assumes that a whole collection, from which a number of instances have been taken at random, has all the common characters of those instances; hypothesis, as an argument which assumes that a term which necessarily involves a certain number of characters, which have been lighted upon as they occurred, and have not been picked out, may be predicated of any object which has all these characters.

There is a resemblance between the transposition of propositions by which the forms of probable inference are derived and the contraposition by which the indirect figures are derived; in the latter case there is a *denial* or change of modal quality; while in the former there is reduction from certainty to probability, and from the sum of all results to some only, or a change in modal quantity. Thus probable inference is related to apagogical proof, somewhat as the third figure is to the second. Among probable inferences, it is obvious that hypothesis corresponds to the second figure, induction to the third, and analogy to the second-third.

Five hundred and eighty-second Meeting.

May 14, 1867. — Monthly Meeting.

The President in the chair.

The Corresponding Secretary read letters relative to exchanges.

The President read a letter from Dr. J. Mason Warren, presenting to the Academy a copy of his work on "Surgical Operations."

The following paper was presented: —

On a New List of Categories. By C. S. Peirce.

§ 1. This paper is based upon the theory already established, that the function of conceptions is to reduce the manifold of sensuous impressions to unity, and that the validity of a conception consists in the impossibility of reducing the content of consciousness to unity without the introduction of it.

§ 2. This theory gives rise to a conception of gradation among those conceptions which are universal. For one such conception may unite the manifold of sense and yet another may be required to unite the conception and the manifold to which it is applied; and so on.

§ 3. That universal conception which is nearest to sense is that of *the present, in general.* This is a conception, because it is universal. But as the act of *attention* has no connotation at all, but is the pure denotative power of the mind, that is to say, the power which directs the mind to an object, in contradistinction to the power of thinking any predicate of that object, — so the conception of *what is present in general,* which is nothing but the general recognition of what is contained in attention, has no connotation, and therefore no proper unity. This conception of the present in general, or IT in general, is rendered in philosophical language by the word "substance" in one of its meanings. Before any comparison or discrimination can be made between what is present, what is present must have been recognized as such, as *it,* and subsequently the metaphysical parts which are recognized by abstraction are attributed to this *it,* but the *it* cannot itself be made a predicate. This *it* is thus neither predicated of a subject, nor in a subject, and accordingly is identical with the conception of substance.

§ 4. The unity to which the understanding reduces impressions is the unity of a proposition. This unity consists in the connection of the predicate with the subject; and, therefore, that which is implied in the copula, or the conception of *being,* is that which completes the work of conceptions of reducing the manifold to unity. The copula (or rather the verb which is copula in one of its senses) means either *actually is* or *would be,* as in the two propositions, "There *is* no griffin," and "A griffin *is* a winged quadruped." The conception of *being* contains only that junction of predicate to subject wherein these two verbs agree. The conception of being, therefore, plainly has no content.

If we say "The stove is black," the stove is the *substance,* from which its blackness has not been differentiated, and the *is,* while it leaves the substance just as it was seen, explains its confusedness, by the application to it of *blackness* as a predicate.

Though *being* does not affect the subject, it implies an indefinite determinability of the predicate. For if one could know the copula and predicate of any proposition, as ". . . . is a tailed-man," he would know the predicate to be applicable to something supposable, at least. Accordingly, we have propositions whose subjects are entirely indefinite, as "There is a beautiful ellipse," where the subject is merely *something actual or potential;* but we have no propositions whose predicate is entirely indeterminate, for it would be quite senseless to

say, "A has the common characters of all things," inasmuch as there are no such common characters.

Thus substance and being are the beginning and end of all conception. Substance is inapplicable to a predicate, and being is equally so to a subject.

§ 5. The terms "precision" and "abstraction," which were formerly applied to every kind of separation, are now limited, not merely to mental separation, but to that which arises from *attention to* one element and *neglect of* the other. Exclusive attention consists in a definite conception or *supposition* of one part of an object, without any supposition of the other. Abstraction or precision ought to be carefully distinguished from two other modes of mental separation, which may be termed *discrimination* and *dissociation*. Discrimination has to do merely with the essences of terms, and only draws a distinction in meaning. Dissociation is that separation which, in the absence of a constant association, is permitted by the law of association of images. It is the consciousness of one thing, without the necessary simultaneous consciousness of the other. Abstraction or precision, therefore, supposes a greater separation than discrimination, but a less separation than dissociation. Thus I can discriminate red from blue, space from color, and color from space, but not red from color. I can prescind red from blue, and space from color (as is manifest from the fact that I actually believe there is an uncolored space between my face and the wall); but I cannot prescind color from space, nor red from color. I can dissociate red from blue, but not space from color, color from space, nor red from color.

Precision is not a reciprocal process. It is frequently the case, that, while *A* cannot be prescinded from *B*, *B* can be prescinded from *A*. This circumstance is accounted for as follows. Elementary conceptions only arise upon the occasion of experience; that is, they are produced for the first time according to a general law, the condition of which is the existence of certain impressions. Now if a conception does not reduce the impressions upon which it follows to unity, it is a mere arbitrary addition to these latter; and elementary conceptions do not arise thus arbitrarily. But if the impressions could be definitely comprehended without the conception, this latter would not reduce them to unity. Hence, the impressions (or more immediate conceptions) cannot be definitely conceived or attended to, to the neglect of an elementary conception which reduces them to unity. On the other

hand, when such a conception has once been obtained, there is, in general, no reason why the premises which have occasioned it should not be neglected, and therefore the explaining conception may frequently be prescinded from the more immediate ones and from the impressions.

§ 6. The facts now collected afford the basis for a systematic method of searching out whatever universal elementary conceptions there may be intermediate between the manifold of substance and the unity of being. It has been shown that the occasion of the introduction of a universal elementary conception is either the reduction of the manifold of substance to unity, or else the conjunction to substance of another conception. And it has further been shown that the elements conjoined cannot be supposed without the conception, whereas the conception can generally be supposed without these elements. Now, empirical psychology discovers the occasion of the introduction of a conception, and we have only to ascertain what conception already lies in the data which is united to that of substance by the first conception, but which cannot be supposed without this first conception, to have the next conception in order in passing from being to substance.

It may be noticed that, throughout this process, *introspection* is not resorted to. Nothing is assumed respecting the subjective elements of consciousness which cannot be securely inferred from the objective elements.

§ 7. The conception of *being* arises upon the formation of a proposition. A proposition always has, besides a term to express the substance, another to express the quality of that substance; and the function of the conception of being is to unite the quality to the substance. Quality, therefore, in its very widest sense, is the first conception in order in passing from being to substance.

Quality seems at first sight to be given in the impression. Such results of introspection are untrustworthy. A proposition asserts the applicability of a mediate conception to a more immediate one. Since this is *asserted*, the more mediate conception is clearly regarded independently of this circumstance, for otherwise the two conceptions would not be distinguished, but one would be thought through the other, without this latter being an object of thought, at all. The mediate conception, then, in order to be *asserted* to be applicable to the other, must first be considered without regard to this circumstance, and taken immediately. But, taken immediately, it transcends what is given (the more imme-

diate conception), and its applicability to the latter is hypothetical. Take, for example, the proposition, "This stove is black." Here the conception of *this stove* is the more immediate, that of *black* the more mediate, which latter, to be predicated of the former, must be discriminated from it and considered *in itself*, not as applied to an object, but simply as embodying a quality, *blackness*. Now this *blackness* is a pure species or abstraction, and its application to *this stove* is entirely hypothetical. The same thing is meant by "the stove is black," as by "there is blackness in the stove." *Embodying blackness* is the equivalent of *black*.* The proof is this. These conceptions are applied indifferently to precisely the same facts. If, therefore, they were different, the one which was first applied would fulfil every function of the other; so that one of them would be superfluous. Now a superfluous conception is an arbitrary fiction, whereas elementary conceptions arise only upon the requirement of experience; so that a superfluous elementary conception is impossible. Moreover, the conception of a pure abstraction is indispensable, because we cannot comprehend an agreement of two things, except as an agreement in some *respect*, and this respect is such a pure abstraction as blackness. Such a pure abstraction, reference to which constitutes a *quality* or general attribute, may be termed a *ground*.

Reference to a ground cannot be prescinded from being, but being can be prescinded from it.

§ 8. Empirical psychology has established the fact that we can know a quality only by means of its contrast with or similarity to another. By contrast and agreement a thing is referred to a correlate, if this term may be used in a wider sense than usual. The occasion of the introduction of the conception of reference to a ground is the reference to a correlate, and this is, therefore, the next conception in order.

Reference to a correlate cannot be prescinded from reference to a ground; but reference to a ground may be prescinded from reference to a correlate.

§ 9. The occasion of reference to a correlate is obviously by comparison. This act has not been sufficiently studied by the psychologists, and it will, therefore, be necessary to adduce some examples to show in what it consists. Suppose we wish to compare the letters

* This agrees with the author of "De Generibus et Speciebus," Ouvrages Inédits d'Abelard, p. 528.

p and b. We may imagine one of them to be turned over on the line of writing as an axis, then laid upon the other, and finally to become transparent so that the other can be seen through it. In this way we shall form a new image which mediates between the images of the two letters, inasmuch as it represents one of them to be (when turned over) the likeness of the other. Again, suppose we think of a murderer as being in relation to a murdered person; in this case we conceive the act of the murder, and in this conception it is represented that corresponding to every murderer (as well as to every murder) there is a murdered person; and thus we resort again to a mediating representation which represents the relate as standing for a correlate with which the mediating representation is itself in relation. Again, suppose we look out the word *homme* in a French dictionary; we shall find opposite to it the word *man*, which, so placed, represents *homme* as representing the same two-legged creature which *man* itself represents. By a further accumulation of instances, it would be found that every comparison requires, besides the related thing, the ground, and the correlate, also a *mediating representation which represents the relate to be a representation of the same correlate which this mediating representation itself represents.* Such a mediating representation may be termed an *interpretant*, because it fulfils the office of an interpreter, who says that a foreigner says the same thing which he himself says. The term representation is here to be understood in a very extended sense, which can be explained by instances better than by a definition. In this sense, a word represents a thing to the conception in the mind of the hearer, a portrait represents the person for whom it is intended to the conception of recognition, a weathercock represents the direction of the wind to the conception of him who understands it, a barrister represents his client to the judge and jury whom he influences.

Every reference to a correlate, then, conjoins to the substance the conception of a reference to an interpretant; and this is, therefore, the next conception in order in passing from being to substance.

Reference to an interpretant cannot be prescinded from reference to a correlate; but the latter can be prescinded from the former.

§ 10. Reference to an interpretant is rendered possible and justified by that which renders possible and justifies comparison. But that is clearly the diversity of impressions. If we had but one impression, it would not require to be reduced to unity, and would therefore not

need to be thought of as referred to an interpretant, and the conception of reference to an interpretant would not arise. But since there is a manifold of impressions, we have a feeling of complication or confusion, which leads us to differentiate the impression from that, and then, having been differentiated, they require to be brought to unity. Now they are not brought to unity until we conceive them together as being *ours*, that is, until we refer them to a conception as their interpretant. Thus, the reference to an interpretant arises upon the holding together of diverse impressions, and therefore it does not join a conception to the substance, as the other two references do, but unites directly the manifold of the substance itself. It is, therefore, the last conception in order in passing from being to substance.

§ 11. The five conceptions thus obtained, for reasons which will be sufficiently obvious, may be termed *categories*. That is,

BEING,
Quality (Reference to a Ground),
Relation (Reference to a Correlate),
Representation (Reference to an Interpretant),
SUBSTANCE.

The three intermediate conceptions may be termed accidents.

§ 12. This passage from the many to the one is numerical. The conception of a *third* is that of an object which is so related to two others, that one of these must be related to the other in the same way in which the third is related to that other. Now this coincides with the conception of an interpretant. An *other* is plainly equivalent to a *correlate*. The conception of second differs from that of other, in implying the possibility of a third. In the same way, the conception of *self* implies the possibility of an *other*. The *Ground* is the self abstracted from the concreteness which implies the possibility of another.

§ 13. Since no one of the categories can be prescinded from those above it, the list of supposable objects which they afford is,

What is.
Quale — that which refers to a ground,
Relate — that which refers to ground and correlate,
Representamen — that which refers to ground, correlate, and interpretant.
It.

§ 14. A quality may have a special determination which prevents

its being prescinded from reference to a correlate. Hence there are two kinds of relation.

1st. That of relates whose reference to a ground is a prescindible or internal quality.

2d. That of relates whose reference to a ground is an unprescindible or relative quality.

In the former case, the relation is a mere *concurrence* of the correlates in one character, and the relate and correlate are not distinguished. In the latter case the correlate is set over against the relate, and there is in some sense an *opposition.*

Relates of the first kind are brought into relation simply by their agreement. But mere disagreement (unrecognized) does not constitute relation, and therefore relates of the second kind are only brought into relation by correspondence in fact.

A reference to a ground may also be such that it cannot be prescinded from a reference to an interpretant. In this case it may be termed an *imputed* quality. If the reference of a relate to its ground can be prescinded from reference to an interpretant, its relation to its correlate is a mere concurrence or community in the possession of a quality, and therefore the reference to a correlete can be prescinded from reference to an interpretant. It follows that there are three kinds of representations.

1st. Those whose relation to their objects is a mere community in some quality, and these representations may be termed *Likenesses.*

2d. Those whose relation to their objects consists in a correspondence in fact, and these may be termed *Indices* or *Signs.*

3d. Those the ground of whose relation to their objects is an imputed character, which are the same as *general signs*, and these may be termed *Symbols.*

§ 15. I shall now show how the three conceptions of reference to a ground, reference to an object, and reference to an interpretant are the fundamental ones of at least one universal science, that of logic. Logic is said to treat of second intentions as applied to first. It would lead me too far away from the matter in hand to discuss the truth of this statement; I shall simply adopt it as one which seems to me to afford a good definition of the subject-genus of this science. Now, second intentions are the objects of the understanding considered as representations, and the first intentions to which they apply are the objects of those representations. The objects of the understanding,

considered as representations, are symbols, that is, signs which are at least potentially general. But the rules of logic hold good of any symbols, of those which are written or spoken as well as of those which are thought. They have no immediate application to likenesses or indices, because no arguments can be constructed of these alone, but do apply to all symbols. All symbols, indeed, are in one sense relative to the understanding, but only in the sense in which also all things are relative to the understanding. On this account, therefore, the relation to the understanding need not be expressed in the definition of the sphere of logic, since it determines no limitation of that sphere. But a distinction can be made between concepts which are supposed to have no existence except so far as they are actually present to the understanding, and external symbols which still retain their character of symbols so long as they are only *capable* of being understood. And as the rules of logic apply to these latter as much as to the former, (and though only through the former, yet this character, since it belongs to all things, is no limitation,) it follows that logic has for its subject-genus all symbols and not merely concepts.* We come, therefore, to this, that logic treats of the reference of symbols in general to their objects. In this view it is one of a trivium of conceivable sciences. The first would treat of the formal conditions of symbols having meaning, that is of the reference of symbols in general to their grounds or imputed characters, and this might be called formal grammar; the second, logic, would treat of the formal conditions of the truth of symbols; and the third would treat of the formal conditions of the force of symbols, or their power of appealing to a mind, that is, of their reference in general to interpretants, and this might be called formal rhetoric.

There would be a general division of symbols, common to all these sciences; namely, into,

1°: Symbols which directly determine only their *grounds* or imputed qualities, and are thus but sums of marks or *terms;*

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* Herbart says: "Unsre sämmtlichen Gedanken lassen sich von zwei Seiten betrachten; theils als Thätigkeiten unseres Geistes, theils in Hinsicht dessen, *was* durch sie gedacht wird. In letzerer Beziehung heissen sie *Begriffe,* welches Wort, indem es das *Begriffene* bezeichnet, zu abstrahiren gebietet von der Art und Weise, wie wir den Gedanken empfangen, produciren, oder reproduciren mögen." But the whole difference between a concept and an external sign lies in these respects which logic ought, according to Herbart, to abstract from.

2°: Symbols which also independently determine their *objects* by means of other term or terms, and thus, expressing their own objective validity, become capable of truth or falsehood, that is, are *propositions;* and,

3°: Symbols which also independently determine their *interpretants*, and thus the minds to which they appeal, by premising a proposition or propositions which such a mind is to admit. These are *arguments*.

And it is remarkable that, among all the definitions of the proposition, for example, as the *oratio indicativa*, as the subsumption of an object under a concept, as the expression of the relation of two concepts, and as the indication of the mutable ground of appearance, there is, perhaps, not one in which the conception of reference to an object or correlate is not the important one. In the same way, the conception of reference to an interpretant or third, is always prominent in the definitions of argument.

In a proposition, the term which separately indicates the object of the symbol is termed the subject, and that which indicates the ground is termed the predicate. The objects indicated by the subject (which are always potentially a plurality, — at least, of phases or appearances) are therefore stated by the proposition to be related to one another on the ground of the character indicated by the predicate. Now this relation may be either a concurrence or an opposition. Propositions of concurrence are those which are usually considered in logic; but I have shown in a paper upon the classification of arguments that it is also necessary to consider separately propositions of opposition, if we are to take account of such arguments as the following: —

Whatever is the half of anything is less than that of which it is the half;

A is half of B:

$\therefore A$ is less than B.

The subject of such a proposition is separated into two terms, a "subject nominative" and an "object accusative."

In an argument, the premises form a representation of the conclusion, because they indicate the interpretant of the argument, or representation representing it to represent its object. The premises may afford a likeness, index, or symbol of the conclusion. In deductive argument, the conclusion is represented by the premises as by a general sign under which it is contained. In hypotheses, something

like the conclusion is proved, that is, the premises form a likeness of the conclusion. Take, for example, the following argument: —

$$M \text{ is, for instance, } P', P'', P''', \text{ and } P^{iv};$$

$$S \text{ is } P', P'', P''', \text{ and } P^{iv}:$$

$$\therefore S \text{ is } M.$$

Here the first premise amounts to this, that "P' P'', P''', and P^{iv}" is a likeness of M, and thus the premises are or represent a likeness of the conclusion. That it is different with induction another example will show.

$$S', S'', S''', \text{ and } S^{iv} \text{ are taken as samples of the collection } M;$$

$$S', S'', S''', \text{ and } S^{iv} \text{ are } P:$$

$$\therefore \text{All } M \text{ is } P.$$

Hence the first premise amounts to saying that "S', S'', S''', and S^{iv}" is an index of M. Hence the premises are an index of the conclusion.

The other divisions of terms, propositions, and arguments arise from the distinction of extension and comprehension. I propose to treat this subject in a subsequent paper. But I will so far anticipate that, as to say that there is, first, the direct reference of a symbol to its objects, or its denotation; second, the reference of the symbol to its ground, through its object, that is, its reference to the common characters of its objects, or its connotation; and third, its reference to its interpretants through its object, that is, its reference to all the synthetical propositions in which its objects in common are subject or predicate, and this I term the information it embodies. And as every addition to what it denotes, or to what it connotes, is effected by means of a distinct proposition of this kind, it follows that the extension and comprehension of a term are in an inverse relation, as long as the information remains the same, and that every increase of information is accompanied by an increase of one or other of these two quantities. It may be observed that extension and comprehension are very often taken in other senses in which this last proposition is not true.

This is an imperfect view of the application which the conceptions

which, according to our analysis, are the most fundamental ones find in the sphere of logic. It is believed, however, that it is sufficient to show that at least something may be usefully suggested by considering this science in this light.

Five hundred and eighty-third Meeting.

May 28, 1867. — Annual Meeting.

The President in the chair.

The following Report of the Council upon the changes which had occurred in the Academy during the past year was presented.

In surveying the events of the past year, as respects the membership of the Academy, the Council would first call attention to the losses which we have sustained, and would put upon record some brief tribute to the memory of our deceased associates. We have lost six Fellows, two Associate Fellows, and one Foreign Honorary Member, — nine in all.

Four of the six taken from our immediate circle, Messrs. Hayward, Mussey, Swett, and Jenks, were well advanced in years; two, Dr. Gould and Dr. Bryant, were suddenly removed from active life and stations which they might have been expected much longer to adorn. All have left names and memories to be affectionately cherished by this society.

James Hayward was born in Concord, Massachusetts, in the year 1786, and died July 27, 1866. His youth was passed on his father's farm, first in Concord, and afterwards in Plainfield, Hampshire County, to which place his father removed when James was eight years old. Anxious to obtain a liberal education, he left his home at the age of eighteen, in the hope of finding in Boston employment that would give him the means of accomplishing his purpose. After three years of fruitless effort he returned to his old home, and took the management of his father's farm, teaching school in winter, and studying at intervals. It was not until 1815, when he was twenty-nine years old, that he was able to carry out his purpose of entering college at Cambridge. Graduating in 1819, he entered the Divinity School, and went through its course, but having been appointed tutor in mathematics in the Col-

lege in 1820, he continued in that office until 1826, when he became Professor of Mathematics and Natural Philosophy. The very next year, however, he resigned his professorship, to devote himself to Civil Engineering; and the same year he was appointed a member of the State Board of Internal Improvements, and also engineer to this Board.

His first work appears to have been a survey, made in 1827, of a line from Boston to Providence for a railroad to be worked by horse-power. This was followed by a survey of a line from Plymouth to Wareham. In 1829 he visited Pennsylvania and Maryland, and made a report on the internal improvements of those States. These and similar labors give him an honorable place among those who introduced the railway system into Massachusetts. Subsequently (1836 to 1845) he was engineer of the Boston and Maine Railroad, the greater part of which was built by him. He was President of this road from 1853 to 1856. Mr. Hayward also took an early interest in the preservation of the harbor of Boston, and was a member of the first Board of Harbor Commissioners. Besides the extended surveys then made, and others ten years later, as a Commissioner on the third Board he was consulted, in 1850, by a Committee of the Legislature on the Harbor, and in 1853 by a Commitiee of the City Government on the Harbor, and made reports to both these bodies. In the former of these reports he recommended the building of a sea-wall along the northern border of the South Boston flats to Fort Independence, which is one of the main features in the present plans for improving the harbor. Mr. Hayward was elected into this Academy in 1834.

At the close of his long and useful career, Mr. Hayward testified his love of science and his interest in the elevation of his fellow-men by many noble bequests. Among the most important of these were three of $ 20,000 each to the Observatory at Cambridge, to the Massachusetts Institute of Technology, and to the Unitarian Association, for the support of foreign missions.

Dr. Reuben Durrand Mussey died in Boston on the 21st of June, 1866, at the age of eighty-six years, having been born at Pelham, New Hampshire, June 23, 1780. His childhood was passed in different country towns of New Hampshire, in which his father successively resided, until, at the age of twenty-one, he entered the Junior class at Dartmouth College. He pursued his medical studies at the same institution, under the tuition of the celebrated Professor Nathan Smith, and afterwards at the University of Pennsylvania, from which

he took the degree of Doctor in Medicine in 1809. Dr. Mussey was a representative of a class not uncommon in New England, of young men early thrown upon their own resources, whose diligence, enterprise, good sense, and indomitable self-reliance have gradually conducted them to elevated positions in society. He was an original thinker, an honest reformer, a leader rather than a follower of public opinion. While a student at Philadelphia he instituted some important experiments on the subject of cutaneous absorption, which gave distinction to his name then and afterwards. He began the practice of medicine at Salem, with much success; and took at once so marked a position that he was elected into this Academy at the anniversary meeting in 1811, fifty-six years ago. He was soon (in 1814) made Professor of the Theory and Practice of Medicine in Dartmouth College, where he was the principal pillar of the Medical School, lecturing simultaneously on three several departments of medical science. His practice, especially in surgery, was large and arduous. His celebrity as a teacher procured for him invitations to join the medical schools of several of the most important cities of the West, and ended in his establishment at Cincinnati as one of the principal professors in the Ohio Medical College. After fourteen years in this service, and six in connection with the Miami Medical College, he resigned his official duties, and returned to spend a serene old age among his friends and kindred in Boston.

Dr. Mussey was a prominent friend of temperance; and his unsparing efforts, both by precept and example, have done much to abate the abuse of stimulating liquors in our own country, if indeed that crying evil can be said to be yet abated. His opinions as to diet were those of an ultraist. It is well known, that he subsisted for the last thirty years of his life without meat or stimulants, confining himself wholly to vegetable food, water, and milk. It is probable that he will not have many followers in this ascetic mode of living; yet, as he enjoyed unusual health and activity of body and mind to a very advanced age, his example, added to others previously known, may at least help to establish the fact that such a diet, when not contra-indicated, is safe and salutary, as it is economical.

Dr. Augustus Addison Gould died in Boston, suddenly, of cholera, on the 15th of September last, in the sixty-first year of his age. He was born at New Ipswich, New Hampshire, April 23, 1805. When old enough to labor, the larger part of the year was given to

his father's farm, — a few winter months to the common school. When only fifteen years old he took the whole charge of the farm, but still managed to secure a few months for study, so that, after a year in an academy, he was able to enter Harvard College, in 1821; although, as he tells us, so ill prepared that his college life was a continual struggle to overcome the barriers which straitened means had placed between himself and the things he aspired to. By severe industry and strict economy he made his way, both as to livelihood and learning, and was graduated with respectable rank. He became a private tutor in Maryland, and at the same time began the study of medicine, which he completed in Boston, passing a year in the Massachusetts General Hospital, as house student, and taking his degree of M. D. in 1830. His struggle with poverty was not yet ended. He had to undertake various tasks, the most Herculean of which was the preparation of the catalogue, in four large folio volumes, of the fifty thousand pamphlets in the library of the Boston Athenæum. But he always found some time for the scientific studies in which he soon became eminent. His taste for Natural History, which had begun to show itself in college, especially in the way of botany, now took its particular bent. His first scientific memoir, communicated to the Boston Society of Natural History, — of which he was one of the earliest, and always one of the most efficient members, — was on the *Cicindelæ* of Massachusetts. The next was a monograph of the species of the genus *Pupa*, found in the United States, in which he points out how their classification might be improved by the use of the microscope. In 1841 he read before the same society a paper on the geographical distribution of the shells of Massachusetts, dealing with considerations which had at that time attracted little attention. He showed the proportion between the marine and the fresh-water species (forty-two of the latter to two hundred and three of the former), and stated that, on a careful comparison, he was unable to satisfy himself that any of the fresh-water species were common to the Old World and the New; and, finally, he indicated the fact that Cape Cod forms an impassable barrier to the extension of many marine species.

But the most considerable of his earlier contributions to science was his Report on the Invertebrate Animals of Massachusetts, chiefly devoted, however, to the Mollusca. Up to this time there had been few if any attempts at so complete a survey of the zoölogy of any particular region of the United States. This fills a volume of 400 pages,

illustrated by more than 200 figures skilfully drawn with his own hands, and every species was described anew, — the whole in a manner to attract the attention and admiration of naturalists, both at home and abroad, and to secure for the author a prominent position in their ranks. His largest and most important work was that upon the shells of the United States Exploring Expedition under Captain Wilkes, the text of which fills a large quarto volume, the illustrations an imperial folio atlas. This was undertaken under peculiar difficulties, growing mainly out of the fact that Captain Couthouy, by whom the collection was chiefly made, had left the expedition before the voyage was finished; that the shells were not well cared for, and were much confused at Washington before Dr. Gould was called to the rescue of this very valuable collection. The published results of his investigation are comprised, not only in the generic and specific characters and descriptions, but in some valuable generalizations and suggestions in the introductory part of the volume, upon geographical distribution, upon what are called representative forms, urging also that animals from widely distant or dissevered regions should be assumed to be different, however close their resemblance, until their identity can be proved, — a rule, the earlier recognition of which would have saved much labor and confusion in the determination of synonymes. He also here indicates the fact that shells of particular and separated regions have each a physiognomy of their own, just as have the human races.

Of Dr. Gould's numerous lesser scientific labors and writings the most noteworthy are his completion of the admirable work on the Terrestrial Air-breathing Mollusca of the United States, left unfinished by the late Dr. Binney; a portion of the Principles of Zoölogy, written conjointly with Professor Agassiz; accounts of collections of shells received from Rev. Francis Mason, missionary to Burmah, from Doctors Savage and Perkins, missionaries to Africa, and from Dr. Bates, U. S. N., from the coast of Liberia; also of collections made in the Pacific Railroad Surveys and other expeditions. These papers all relate to conchology, in which he was high authority. But that his scientific interests and activities were not restricted is well known to his associates in this Academy, and in the Natural History Society, and may be seen from his communications upon a great variety of topics, printed in their Proceedings, or often merely referred to; for he seldom wrote out his communications, and thus much of value has been lost.

In considering as we have done Dr. Gould's various and fruitful labors as a naturalist, it must not be forgotten that these were performed in the intervals of the duties of a most exacting profession, to which he was thoroughly devoted, and in which he was distinguished. He called one of his books, in which the fruits of his principal conchological work are usefully gathered and systematized, *Otia*, being, as he says, "the product of leisure moments in active professional life, and indeed of moments to no small extent stolen from sleep."

Of the high estimation in which he was held by his medical brethren we need not here speak. His term of service as President of the Massachusetts Medical Society ended only a few months before his death. His inaugural address, pronounced at the anniversary of that society, upon the Observation of Nature, was a masterly discourse, and shows better than his technical writings could do the range and the solid character of his mind. By an analysis of some of the facts contained in the census of the United States for 1860 Dr. Gould was enabled to bring out and confirm certain important conclusions respecting the geographical distribution of consumption; from which it appears that the greatest mortality from this disease occurs in the extreme north; and that this diminishes southward almost regularly with the latitude, — causing, for instance 29 per cent of all the deaths in Maine; but only 3 per cent in Arkansas. He adds some valuable suggestions as to the choice of places of resort for invalids, especially for disabled soldiers of the United States.

As a citizen Dr. Gould, upon principle, never excused himself from his full share of duty on the ground of professional or scientific preoccupations; but in the public schools and charities, in the religious society which he joined in early life, and in the scientific and various other associations of which he was an honored and influential member, he well exemplified the rule that those who are busiest are apt to have most leisure to be helpful.

A model of industry, he seldom rested from toil, and to the end each day was full to the round. Yet he found time for social intercourse, if not as much as his genial temperament and sympathetic nature craved; and he enjoyed it, when he could, with real zest. His refined taste and exact knowledge made him a discerning and judicious critic; and during his life many volumes, scientific and other, passed under his eye for friendly revision.

His love for natural scenery was genuine and hearty, and to him a

source of great enjoyment, especially when he could share it with others. Unlike many naturalists to whom the shores they tread and the mountains they climb offer nothing beyond the forms they would describe and arrange, all else being as if it were not, our late associate (than whom no one ever toiled more industriously over individual forms and nice distinctions) was touched and warmed by every aspect of nature, in its grander and gentler scenes; not that he was peculiarly enthusiastic or emotional, but rather from the delicate perception and calm contemplation of a refined, devout, and responsive spirit.

He was elected into this Academy in May, 1841, and for many years he rendered useful service in various offices.

Dr. Henry Bryant, whom we lost as suddenly and unexpectedly as Dr. Gould, and from the same section of the Academy, died in Porto Rico, on the 31st of January last, in early manhood, not having completed his forty-seventh year. He was born in Boston, May 12, 1820; entered Harvard College in 1836, and was graduated in 1840, without literary distinction, but with a mind awakened to the attractions of natural science. After taking his degree of Doctor of Medicine, in 1843, he went to Paris to prosecute further his professional studies. There he received, after severe competitive examination, the post of *interne* at the Hospital *Beaujou*; but was soon obliged by ill health to resign it. Partly for the re-establishment of his health, he accepted the invitation of some officers of the French army to accompany them to Algeria, where he served during a winter campaign as volunteer surgeon.

He came home in 1847, and commenced the practice of his profession. But his precarious health obliged him finally to abandon it. Thenceforth he devoted his time principally to natural history, and particularly to ornithology, which had been a favorite pursuit from boyhood. This was the occupation most suitable to his delicate health, as it led him to live a good deal in the open air. He visited, in the way of scientific exploration, Nova Scotia, Canada and Labrador, Florida and the Bahamas, Cuba, Jamaica, and Porto Rico, some of them repeatedly, — to the great profit of his favorite science, as is shown in the various ornithological papers he communicated to the Boston Society of Natural History. Besides these papers, he made, while in Paris, a communication to the French Academy of Sciences, on the nervous system of birds, which is published in the *Comptes Rendus* for 1848.

Dr. Bryant was a very vigilant and acute observer, — one who

always insisted upon seeing with his own eyes, and was not overmuch inclined to reverence authority, or rely on commonly received statements. Not only were his own personal services very considerable in the exploring of regions difficult of access, or in the investigation of facts difficult to observe; but when, as of late years, he could command the means, these were liberally given in aid of other explorers in his favorite fields.

At the outbreak of the Rebellion he went at once to Washington and offered his services to the government. Commissioned as assistant surgeon in the regular army, without waiting for a position he accepted that of surgeon in the Twentieth Regiment of Massachusetts Volunteers in July, 1861, and was made brigade surgeon in the following September, but remained with his regiment until after the disaster of Ball's Bluff in October. Afterwards he served on the staffs of Generals Lander and Shields, until he was ordered to Washington to take charge of the Lincoln Hospital, — one of the first large hospitals established, while the medical department of the army was as yet imperfectly organized, so that the whole responsibility for plan and execution came mostly upon the surgeon in charge. In this position Dr. Bryant's remarkable talent for administration was conspicuous; and his hospital was pronounced, by professional men, to be admirable. His failing health obliged him to resign his commission before the close of the war. Afterwards he went abroad with his family; and in France he bought and presented to the Boston Society of Natural History the *La Fresnaye* collection of birds, comprising nearly nine thousand specimens, and probably unequalled in types of American species by any cabinet in Europe. Returning home late in the year 1866, he sailed for the West Indies, as winter drew on, intending thence to rejoin his family in France, and in spring to return home with them. Landing at Porto Rico, he was seized, on the 30th of January, with a severe illness, of uncertain character, but rode with great suffering twenty-five miles to Araceibo, where, the next day, he closed — for us, far too soon — a life of rare excellence and promise.

Rev. Dr. William Jenks, — the most venerable of our late departed associates, — died in Boston on the 13th of November last, in the eighty-eighth year of his age. He was born at Newton, Massachusetts, November 25, 1778, and was the son of Captain Samuel and Mary (Haynes) Jenks. His parents having removed to Boston in his early childhood, he received a classical education in the Latin School,

and entered Harvard College in 1793, where he was devoted to the study of Greek, and was one of the founders of the Hasty Pudding Club. He was graduated in 1797, and at his death left the Hon. Horace Binney, of Philadelphia, the only survivor of his class. He married, October 22, 1797, Miss Betsey Russell of Boston, with whom he enjoyed fifty-three years of domestic companionship, as the mother of his children and his associate in varied professional cares, till her death in Boston in September, 1850. He and his wife were among the first in the country to celebrate a "golden wedding." As a teacher, pastor, and scholar in classical and Oriental studies, and as a most earnest and devoted laborer in various causes of humanity and philanthropy, he was enabled to crowd a long life with much valuable service.

After his graduation he devoted himself to the work of instruction, having pupils from various parts of the country. While pursuing the study of Theology he was employed as reader in the Episcopal Church in Cambridge, and prepared twenty-five students for college. Having adopted the views and principles of the Congregationalists, he accepted, in 1806, a pastorate in that communion at Bath, Maine, which he filled for twelve years. During the last three of those years he served as Professor of Oriental and English Literature in Bowdoin College, declining an invitation which he had received to succeed the eminent Dr. Buckminster in the ministry at Portsmouth, New Hampshire. He was ever an active friend of Bowdoin, and for many years a trustee and overseer. The degree of Doctor in Divinity was conferred upon him by Bowdoin College in 1825, and by Harvard in 1842, and that of Doctor of Laws, at a subsequent period, by the former college. While living in Maine, Mr. Jenks was Regimental and afterward Brigade Chaplain in our army, till the close of the war of 1812.

In 1818 Mr. Jenks returned to Boston, and opened a private school; continuing, however, to preach as opportunity offered, interesting himself in the religious instruction of seamen, for whom he procured the erection of free chapels, in which he ministered. He performed this service as Secretary of the Boston Society for the Moral and Religious Instruction of the Poor, being, in fact, the first "missionary at large" in the city. He opened seven distinct religious assemblies in as many different localities, which generally became established churches. His zeal, and the high estimation in which he was held, led to the gathering of a new religious society and church, who built a place of worship in Green Street, installing him its pastor in 1825, for

a ministry of twenty years. While sustaining this office he undertook and completed the chief literary labor of his life, — the preparation and publication of a compend of various expository and illustrative works on the contents of the Holy Scriptures. This appeared from the press during the years 1833 - 1838, in six imperial octavo volumes, entitled "A Comprehensive Commentary on the Holy Scriptures," a list of twenty thousand subscribers having anticipated its publication. He also, subsequently, prepared his "Explanatory Bible Atlas." He was among the very first in the circle of our literary men to cultivate and pursue the study of the Oriental languages and literature; and, in connection with our late President, the Hon. John Pickering, and the Rev. Dr. Anderson, he led the way in founding the American Oriental Society. He was also an active member of the Massachusetts Historical Society. His acquaintance with the present State of Maine, while it was a District of Massachusetts, and his known philanthropical and religious interest in the aborigines, led to his appointment by this Commonwealth to induce the Indians to exchange a roaming life as hunters for that of permanent residents and tillers of the soil.

For all his trusts and duties he proved himself a most faithful and efficient agent. He gathered a large and valuable library, characteristic in its contents of his own mind and tastes. He wrote for publication numerous papers, small and brief in their size and contents, but requiring scholarship, research, and the exercise of intelligent judgment, in their subject-matter. Some of these appeared in pamphlet form, others will be found in the Collections, Transactions, or Proceedings of the Societies of which he was a member. There are poetical pieces above ordinary merit from his pen, and he left in manuscript many valuable fruits of his industrious and lengthened life.

The large and very miscellaneous library, the manuscripts and diaries which this venerable man has left behind him, bear witness alike to his conscientious industry, the wide scope of his mental activity, and the pure and lofty aims of his heart. It is to be considered that he engaged upon the most difficult linguistic studies, even of the languages of China, Hindostan, Turkey, &c., before commerce or missionary zeal, or the accumulation of the many facilities and the helpful apparatus of our times had brought to the aid of the inquirer any external guidance or labor-saving appliances. Yet, when actual need was felt in our community of men and information for opening the way to the extended intercourse and the Christian enterprise of the last forty

years, Dr. Jenks proved to be a most valuable pioneer and counsellor. He had never crossed the ocean; but it is believed that he could have imparted valuable information touching their own countries, in his own home, to travellers hither from all parts of the world.

The personal character of this excellent man, distinguished as he was by many virtues, and beloved for his winning and gracious ways, deserves for its rehearsal more space than could be fitly occupied here. He was short in stature, and distinguished in bodily presence by one characteristic which has marked him during the last few years as he walked the streets, as he attended the meetings of the learned, the humane, or the religious fellowships in which his mind and heart were so engaged, or silently shared the platform or the pulpit close beside the speakers. An infirmity of hearing visited upon him a severe deprivation of what he craved so much. He carried with him a large ear-trumpet which he set upon its office when a friend approached to speak with him, or when he put a question which required an answer. The exquisite urbanity and courtesy of his manner, his venerable looks, and his grateful appreciation of the effort made to communicate with him, removed all the irksomeness and constraint from that fettered mode of intercourse. He seemed to be the last survivor of the old school of Christian gentlemen among us, — modest, deliberate, and refined in his bearing; considerate and measured in his speech, and carrying with him everywhere an atmosphere of grace and gentleness. He was a profoundly religious man. His relations and intercourse with eminent and worthy as well as with humble and untaught members of the different religious fellowships, and the wide compass of his studies, gave him a most comprehensive friendliness, and a large liberality. He exhibited constant fidelity to his own convictions, with a strong allegiance in love with those who coincided in them, and a most respectful recognition of views from which he differed, and of those who held them.

Colonel Samuel Swett, who died in Boston on the 28th of October last, had reached the age of eighty-four years. He was born at Newburyport June 9, 1782; was prepared for college at the Grammar School of his native town by his father, Dr. John Barnard Swett; and received his degree of Bachelor of Arts at Harvard, with the class of 1800. Having studied law, first with Judge Jeremiah Smith of New Hampshire, and afterwards with Judges Jackson and Livermore of Massachusetts, he commenced the practice of his profession at Salem in

1803, but relinquished it in 1810, to become a partner with his brother in the mercantile house of William B. Swett & Co. in Boston, having in the mean time married a daughter of the eminent merchant, the late Hon. William Gray. Soon after the breaking out of the war of 1812 he was active in organizing a volunteer corps in Boston, under the name of the New England Guards, of which he was the first commander, and which, under his lead, rendered important service in defence of our coast and harbor. Joining the United States Army as a volunteer, in 1814, he served as a topographical engineer on the staff of General Izard, with the rank of Major. After the declaration of peace he was an aid-de-camp to Governor Brooks, and was ever afterwards known as Colonel Swett. He had a strong taste for military service, and devoted not a little study to the science of war, even to the latest years of his life. Few men followed the campaigns of the late Rebellion with more intelligent and patriotic ardor, or were more ingenious and fertile in the suggestion of whatever might contribute to the comfort, safety, and success of the Union soldiers. He was a member, successively, of the Common Council and of the School Committee of Boston, and for three years one of its Representatives in the Legislature. He was a frequent contributor to some of our magazines and newspapers; and, on his return from Europe, whither he had gone about the time of Napoleon's return from Elba, he published in the Boston Daily Advertiser an account of his tour, and of the events he had witnessed during the memorable Hundred Days. His principal, if not his only, independent publication, however, was an elaborate account of the Battle of Bunker Hill, in a pamphlet, which went through more than one edition. He was elected into the Academy in May, 1813.

Of his five children, two sons and a daughter survive him; but his wife died in 1844, and his eldest son, a Unitarian clergyman of many remarkable gifts, in 1843. Colonel Swett bore his bereavements and infirmities with a brave heart; and his familiar figure, though sorely bent by age, was seen in our streets, and at the meetings of our own Academy, until within a few months of his death.

Henry Darwin Rogers, for many years one of our most distinguished Resident Fellows, and whose name was, in consequence of his change of abode, transferred to the Associate list two years ago, died at Shawlands, near Glasgow, upon the very day of our annual meeting last year, namely, on the 29th of May, 1866. Born in Phila-

delphia on the 1st of August, 1808, he had not completed his fifty-eighth year.

He was the third in age of four brothers, — only two of whom survive, — who, inspired and guided by their father, Dr. Patrick Kerr Rogers, Professor of Natural Philosophy and Chemistry in William and Mary College, Virginia, — as if by mutual agreement, all gave their lives to the cultivation and teaching of physical science. From his youth, the subject of the present notice evinced so decided a predilection for these studies and became so proficient in them, that, in his twenty-second year, he was made Professor of Physics and Natural History in Dickinson College, at Carlisle, Pennsylvania, where, at the same time, he edited a periodical called a "Messenger of Useful Knowledge." Here he began his first independent studies in structural and dynamical geology, in which he was destined greatly to excel.

Seeking better opportunities, he soon resigned his chair, and passed a year in England, studying chemistry under the late Professor Turner, and accompanying the late De la Beche in his geological explorations. Returning to Philadelphia, he devoted his whole time to scientific investigations. In conjunction with our other lately deceased associate, Professor Bache, he made and published a valuable series of analyses of the ashes of coal; and he aided his brother, our own William B. Rogers, in experiments upon "the laws of the Voltaic battery" (published in Silliman's Journal), and in preparing two memoirs upon "the Tertiary Formations of Eastern Virginia," which were published in the Transactions of the American Philosophical Society. At the request of the Council of the British Association for the Advancement of Science, he prepared a report on the Geology of North America, which was printed in the third Annual Report of that body, and was in part republished in this country in Bradford's edition of Murray's Encyclopædia of Geography.

His first systematic geological labor was that of conducting the survey of the State of New Jersey, of which he published a report in 8vo, with a geological map. While thus engaged a similar survey of the great State of Pennsylvania was provided for by the Legislature, and placed under his direction. This, the most important scientific labor of his life, was commenced early in the year 1836, and, with various interruptions and embarrassments growing out of legislative inaction, was completed by him in the spring of 1855. The fruits of these prolonged labors have been given to the world in his great work en-

titled "Geology of Pennsylvania, Government Survey; with a General View of the Geology of the United States, Essays on the Coal Formation and its Fossils, and a Description of the Coal Fields of North America and Great Britain." This great work is contained in three royal quarto volumes, illustrated by forty-five sketches of scenery, forty-seven geological sections, two plates of columns of strata, twenty-three plates of coal fossils, and seven hundred and seventy-eight wood engravings of views and diagrams of coal-beds, &c., and accompanied by a general geological map of the State, a special map of the anthracite coal-basins, and two large sheets containing the nine general sections, elucidating the geological map.

During the early progress of this work he produced, in conjunction with his brother, William B. Rogers, the well-known memoir "On the Physical Structure of the Appalachian Chain," unfolding certain dynamical laws which have regulated the elevation of mountain chains. About the same time (1842) he published an elaborate paper on the origin of the Appalachian coal strata, bituminous and anthracitic, containing much original observation and important speculative views; his brother pursuing a parallel system of investigations in Virginia, where the formations are identical with those of Pennsylvania. The result of the labor of these two brothers, carried on for ten years together, was the grand discovery of the structural unity of central North America, between the Appalachian chain and the Rocky Mountains, the great lakes and the Delta inclusive; a fact of such importance that it must serve in future as a guide to all general researches; since it is not reasonable to suppose that so large a portion of the earth's surface should have been formed in any other than the normal mode. Occupying at this time the chair of Geology in the University of Pennsylvania, he gave instruction in that science in the intervals of his labors on the State Survey. He also delivered courses of lectures at the Lowell Institute and elsewhere; on all such occasions showing that readiness and felicity of diction, without the use of notes, for which he had always been remarkable.

He was one of the founders, and an early President, of the American Association of Geologists, which, after an active and most useful career, expanded into the American Association for the Advancement of Science. Although chiefly devoted to geological research, Professor Rogers paid much attention to those sciences of which geology is the extended application, — Natural History, Climatology, and Physical Geography.

In 1855 he contributed to Keith Johnson's Physical Atlas the Geological Map of the United States and British North America; and the Chart of the Arctic Basin, with the accompanying letter-press, and the text of the somewhat later Geographical Atlas of North America, is from his pen. The philosophical questions arising from these studies especially interested him; indeed, the whole bent of his mind was in an eminent degree philosophical rather than technical.

In the year 1857, while in Edinburgh superintending the publication of his Geological Report, he was appointed Regius Professor of Natural History and Geology and Curator of the Hunterian Museum, in the University of Glasgow, and thenceforth became a resident of Scotland. While devoting himself to the duties of his chair, he became associated with Jardine and Balfour in the editorship of the Edinburgh New Philosophical Journal, contributed a paper on "The Laws of Structure of the more disturbed Zones of the Earth's Crust" to the Transactions of the Royal Society of Edinburgh, and found time for a number of scientific essays, published in Blackwood and Good Words, as well as for occasional lectures on his favorite geological topics in London, Edinburgh, and elsewhere.

On revisiting, as it proved for the last time, his native country, in 1855, his friends were concerned to see that his health had given way under his prolonged and excessive labors, overtasking a constitution, elastic indeed, but not naturally robust. He returned to Glasgow, reinvigorated it was thought; but we soon heard, with sorrow, that he was no more.

Although the eminent position in geology held by our late associate, and somewhat of the nature and dominant influence of the general views of the associated brothers, may be inferentially gathered from this biographical sketch, yet we are, for obvious reasons, prevented from entering upon their consideration here, nor indeed is it necessary to do so. Of him whom we have lost, suffice it to record, here, in simplest and briefest phrase, that he was a most accomplished investigator, a graceful and persuasive teacher, and fascinating companion; that to rare powers and attainments he added a lively sympathy in all the interests of humanity, and a courageous devotion to whatever he deemed just and true.

Alexander Dallas Bache, born in Philadelphia on the 19th of July, 1806, was the son of Richard Bache, and grandson of the only daughter of Benjamin Franklin. His mother was Sophia Dallas,

daughter of Alexander J. Dallas, of a family also well known in the history of this country. Remarkable from early boyhood for his aptitude in the acquisition of learning, he was appointed a cadet in the National Military Academy at West Point before he had completed the fifteenth year of his age. Here, although the youngest pupil, he soon reached a high grade of scholarship, and maintained it throughout the course, graduating in 1825 at the head of his class; — a class of such marked ability that it furnished no less than five successful candidates to the corps of Engineers. It has been mentioned as a solitary instance in the history of the Academy, noted for its rigid discipline, that he passed through the entire course of four years without a single mark of demerit, and, what may be hardly less uncommon, without calling forth the least manifestation of envy. Indeed his classmates, as well as the teachers, seem to have taken pride in the high character and scholarship of the youthful cadet. His room-mate, several years his senior, and by no means noted for studious or regular habits, assumed the office of guardian, sedulously protecting him from interruption or intrusion during the hours of study, and, it is said, habitually excused his own shortcomings by pleading the importance of the duty he thus performed. Not that young Bache himself needed a guardian, except for his tender years and to protect him from hindrance on the part of others. Sensible beyond his years of the responsibility which would devolve upon him in the support of his widowed mother and her younger children, and of the obligations incurred in his education at the National School, he resolved from the first to exert his utmost energies, — doubtless not unconscious, moreover, that, as a descendant of Franklin, something more than ordinary might be expected from him. Upon such a mind as his, the adage *noblesse oblige* could not but have a powerful influence.

Upon his graduation he was selected, on account of his high standing, to remain at the Academy as Assistant Professor, — a position which gave him a desired opportunity to review and extend his studies. But after a year in this service he was, at his own request, assigned to engineering duty at Newport, Rhode Island, under the late General, then Colonel Totten. Here for two years he was engaged in constructing fortifications, devoting his extra hours to the study of physics and chemistry.

The most important event of this period, however, and doubtless the most influential upon his future success, was the acquaintance and

engagement he formed with Miss Fowler, the daughter of an old and highly respected citizen of Newport. The scanty pay of a Lieutenant of Engineers, charged with the support of his mother and the younger members of her family, forbade all but the remote prospect of marriage; when, fortunately as unexpectedly, he was invited to take the chair of Natural Philosophy and Chemistry in the University of Pennsylvania, at Philadelphia. This, while it opened to him his scientific career, enabled him at once to gratify the warmest wish of his heart, and to secure the companion and helpmate, who, devoting all her thoughts and powers to encourage and assist him, contributed most efficiently to his distinguished usefulness throughout his active life.

Important as was the offered position to his hopes and necessities, and congenial to his tastes, the young officer so far distrusted his ability to fill it, that he prudently retained his connection with the army while the trial was made, — taking a year's leave of absence without pay. But before the year elapsed his fitness for the vocation was assured, and the entire confidence of the authorities and pupils of the University secured. He could now undertake to do something for the advancement of science by researches of his own. He became a member, and soon an active officer of the Franklin Institute, then newly established for the promotion of the mechanic arts, and was thus brought into intimate association with the principal manufacturers, engineers, and artisans of the city, as well as with persons more directly engaged in scientific pursuits; workshops and laboratories were thrown open to him, and other facilities supplied which he could not otherwise have commanded; and skilful men on every side offered ready assistance in realizing the conceptions of his suggestive mind. No doubt his descent from the illustrious philosopher and statesman, whose name the Institute bears, added somewhat to the commanding influence which he acquired, mainly and worthily, however, by his own industry, ability, courtesy, and rare powers of administration. The volumes of the Journal of the Franklin Institute, from 1828 to 1835 inclusive, abundantly testify to his scientific activity.

The most important of these investigations was that upon the causes of the explosion of steam-boilers, carried on by the Institute under his direction, and soon recognized by the General Government by an appropriation to cover the expense. The results of these elaborate researches and experiments, executed with skill and interpreted with logical discrimination, were embodied in a series of propositions which,

after the lapse of more than thirty years, have not been superseded by any others of more practical value. The most frequent cause of explosion was found to be the sudden generation of steam from allowing the water to become too low, and its subsequent contact with the overheated sides of the boiler. Other assigned causes, such as the generation of gas from the decomposition of water, or the dispersion of water in the form of spray through superheated steam, were successively disproved.

Early elected into the American Philosophical Society, Professor Bache was then associated with Hare, Espy, and other investigators. Erecting for the purpose an observatory in the yard of his dwelling, and with the aid of his wife and his pupil, afterwards his successor, Professor Frazer, he accurately determined, for the first time in this country, the periods of the daily variation of the magnetic needle, and afterwards, the connection of the fitful variations of the direction of the magnetic force with the appearances of the aurora borealis. He also, in connection with Mr. Espy, made a minute survey of the relative change of position of the trees and other objects upturned by a tornado which passed over New Brunswick, New Jersey; and deduced the fact that the tornado was a progressive and ascending column of rarefied air, to which objects at a distance on either side of the track were drawn; and not a horizontal rotation at the surface, which would tend to throw them outward. In connection with Professor Courtenay he made a series of determinations of the magnetic dip at various places in the United States. Terrestrial magnetism was with him a favorite subject, to which he continued to make valuable contributions at intervals during his life. He was also interested in the phenomena of heat; and he was the first to show, contrary to the generally received opinion, that the radiation, and consequently the absorption, of dark heat is not affected by color.

It should be noticed that these investigations were prosecuted in the intervals of time not occupied by his duties as Professor in the University, into which his main strength was heartily thrown, and which absorbed several hours a day, nor claimed by committees of the Franklin Institute and the Philosophical Society. He was enabled to execute these multifarious labors, and to establish his character for promptitude in all his engagements, by rigid system and an exact allotment of his time. He thus found opportunity for all his duties, and, among them, to attend to the claims of friendship and society.

Professor Bache had just attained the thirtieth year of his age when, in 1836, the Trustees of the Girard College for Orphans, preparatory to organizing that nobly-endowed charity, determined to select a suitable person as President, and to send him abroad to study the organization and methods of instruction of similar institutions in Europe. The eyes of the community being with one accord turned to him, he was prevailed upon to accept this important position, and — with lingering regret for the scientific pursuits from which he was likely to be separated — to turn his attention and powers of administration in a new direction. He visited Europe under the most favorable circumstances for becoming intimately acquainted with its scientific and educational institutions; he devoted two years to the work, and, on his return, embodied the results in his well-known Report to the Trustees of Girard College. This report fills a large 8vo. volume, and is an almost exhaustive exposition of the systems of education in use at the time in the schools of England, France, Germany, Switzerland, and Italy, — the facts all founded on personal inspection, and recorded on the spot with his habitual regard to entire accuracy; and the practical inferences and pregnant suggestions with which it abounds show how thoroughly he had entered into a new line of inquiries.

He was now ready to commence the organization of the College; but this being deferred by the Trustees, Professor Bache, desirous of turning the knowledge he had acquired to immediate practical account, offered his services gratuitously to the municipal authorities of Philadelphia, and entered upon the organization of a system of public education for that city on an improved basis. At the end of a year, finding the Trustees of Girard College still unprepared to open the institution, he declined the salary while yet retaining the office of President, and devoted his time mainly to the organization of the schools, now accepting from the city the salary needful for his support, but much smaller than that he relinquished.

In 1842, having successfully established what was regarded as the best system of combined free education which had at that time been adopted in this country, and Girard College still remaining in a statical condition, he resigned his connection with it, and, yielding to solicitations of the Trustees of the University, returned to his former chair of Natural Philosophy and Chemistry. He could now resume the favorite pursuit of his life, the cultivation of physical science, — which, however, he had never wholly abandoned. While abroad,

with a set of portable instruments, he kept up a series of magnetical observations at selected points, with the view of accurately ascertaining the relative strength of the magnetic force in Europe and America, by comparison with parallel observations made in this country. He had also engaged in the combined enterprise, proposed and furthered by the British Association, to determine the fluctuation of the magnetical and meteorological elements of the globe by contemporaneous observations at many widely separated stations. For this he established an Observatory at Girard College, which was equipped with instruments by the Trustees, and supported by the American Philosophical Society and several liberal citizens. The observations here made, which were kept up, at intervals of one and two hours, night and day for five years, form a rich mine of statistics from which, down to the last two years of his life, he continued to draw interesting series of results without exhausting the material.

A new epoch in Professor Bache's life now approached. Before he was well settled in his old position at the University, in November, 1843, upon the death of Mr. Hassler, he was called to the charge of the United States Coast Survey, of which for about twenty years he was the efficient and distinguished head. His education at West Point, his well-proved skill in investigation, his thorough familiarity with the principles and details of applied science, all the acquisitions and experience of his previous life, and, not least, his placid and even temper, urbane deportment, exquisite tact, and executive ability, all conspired to his eminent fitness for the place, and to the achievement of the immense development and complete success of this great national undertaking in his hands. We cannot enter here into the history of the United States Coast Survey, intimately connected as it is with that of its late superintendent. It must suffice to say, that when Professor Bache took charge of it, the survey was in its infancy, had touched upon only four or five hundred miles of the Atlantic coast, was subject to misapprehension, annually assailed by ignorant prejudice, and in danger of being suspended or abolished. Before he died, it had extended its lines over the whole coast of the national domain, upon both oceans, from the Bay of Fundy to the Rio Grande, and from San Diego to Puget Sound; had conquered unjust prejudice, silenced opposition, and now passes into the charge of our associate the present incumbent, firmly established as one of the bureaus of the Executive Government.

The importance of the survey, always appreciated by the mariner, was recently impressed upon the general public, by the essential service which it rendered during the war of the rebellion. Its accurate charts and sailing directions guided our squadrons along the Southern coast; its officers accompanied and piloted them in the attack upon every stronghold; the superintendent himself was personally called into frequent consultations over plans of attack or defence; besides serving upon an important confidential commission, to which various projects for improving the art of war were referred, and also as a member of that great voluntary association for the relief of imminent wants and mitigation of the soldier's suffering, the Sanitary Commission. Indeed Mr. Bache may be ranked among the victims of the service; for it was when, overwhelmed with other public labors, he planned, at the request of the Governor of the State, a line of defences for his native city of Philadelphia, and was personally superintending their construction, that his health gave way under the first indications of the cerebral disease which not long afterwards arrested his labors, gradually and peacefully withdrew him from the outer world, and nearly three years afterwards terminated his invaluable life. He died on the 17th of February, 1867, in the sixty-first year of his age.

The amount and value of Mr. Bache's labors and public services would be much under-estimated if we omitted to state that he was likewise, while at the head of the Coast Survey, the Superintendent of Weights and Measures, in which capacity he completed the work, begun by Mr. Hassler, of constructing accurate standards for distribution among the several States of the Union; — that he was one of the Commission appointed to examine the condition of the Lighthouses of the United States, bore a leading part in the organization of the admirable system now in operation, and continued to be an influential member of the Lighthouse Board in which the original Commission was merged; that he was the President of the National Academy of Sciences recently chartered by Congress; — and, finally, that he was one of the Regents of the Smithsonian Institution, named in the act of incorporation in 1846, and was continued in this important trust by successive re-elections until his death. To him probably more than to any other member of the Board the credit is due of shaping the policy of the establishment, of retrieving initial mistakes, and of securing the appropriation of the income of this most important trust mainly to the advancement of science.

In all these positions, and especially in the often difficult management of the affairs of the Coast Survey, his extraordinary influence and success may be attributed to his sterling honesty and simplicity as well as fixedness of purpose, to the even balance of a symmetrically developed and well-stored mind, to a quiet winning persuasiveness which, on a personal interview, rarely failed to convert even an opponent into a friend, and, in a word, to a consummate practical wisdom and shrewdness which may somewhat remind us of his distinguished ancestor. The conduct of affairs and details of administration which absorbed most of his best years, and for which he was so peculiarly fitted, took from him the opportunity of doing much that he had planned and might have done in original investigation. But even in this field he has left a name not unworthy of his lineage.

VICTOR COUSIN, the only Foreign Honorary Member deceased during the past year, died at Paris, about the middle of January last, in the 75th year of his age. His career has been long, brilliant, and prosperous. For nearly half a century his name has been indisputably the first among the philosophers of France, while his numerous writings have occupied and rewarded the attention, not only of the special students of psychological and metaphysical science, but of educated and thoughtful men generally. Though not well fitted either by his tastes or habits to gain political distinction, or to hold high office in the state, he was for a while a prominent member of that remarkable group of men, eminent in letters and science, who were the legislators and statesmen of France under Louis Philippe; he was created Councillor of State, member of the Royal Council of Public Instruction, Peer of France, and finally entered the Cabinet under the short-lived ministry of Thiers, in 1840, as Minister of Public Instruction. After the defeat of that ministry, he retired to his old pursuits and apartments in the Sorbonne, where he occupied, as a bachelor, the same rooms almost continuously for nearly thirty-five years, constantly employed on his numerous and successful publications, collecting a noble library, amassing an ample fortune, and leaving at his death both his books and money for the encouragement of philosophical studies.

That Cousin was able to accomplish so much, though he began life without any extraneous advantages, indicates what has been the essentially democratic constitution of society in France during the first half of the present century, whatever may have been for the time its nominal form of government. Mobility of fortune and station, splendid

prizes for ambition, and a career open in any direction for talents and character have stimulated youthful effort at Paris ever since the Revolution of '89. Cousin entered upon the stage at the right time, and with the right temperament, to profit by these advantages. He was the son of a watchmaker at Paris, where he was born November 28, 1792. He finished the earlier part of his education at the Lycée Charlemagne, obtaining a number of prizes at the competitive examination, and the first honors in the department of rhetoric. Then he became a pupil in the Normal School, where, under the tuition of Laromiguière, Royer-Collard, and Maine de Biran, he completed his elementary training in philosophical studies with so much promise that he was placed in the way of rapid promotion as a teacher. He became Tutor of Greek in this school in 1812, and Master of Conferences in Philosophy only two years afterwards, acting at the same time as a Professor in this department in the Lycée Napoleon. In 1815, at the early age of twenty-three, he was appointed Adjunct Professor to Royer-Collard in the chair of Philosophy at the Faculty of Letters in the Sorbonne, taking upon himself, as is usual in such cases, the entire performance of the duties of the office, his principal then virtually quitting philosophical for political pursuits, and retaining the Professorship only as a sinecure. Never was rapid advancement in a high profession more fairly earned, or better justified by the result. With great facility of acquisition, and an immense capacity for labor, Cousin had also the ardent temperament, the unflagging interest in his vocation, and the rhetorical power which are needed to attract and animate a band of zealous young disciples. With such he soon found himself surrounded; and ten years afterwards he was able to allude with excusable pride to the fact, that the three most distinguished graduates of his first class in philosophy at the Normal School, in 1816, were Bautain, Jouffroy, and Damiron. Indeed, it may fairly be said of him, that his best works at this early period were his pupils.

Yet his pen was by no means idle; he fed the press with a succession of voluminous publications, any one of which would have cost most men many laborious years. Before 1827, he had completed an edition of Proclus, edited from the MSS., with notes, in six octavo volumes; about the same time appeared his edition of Descartes, in eleven volumes; and while these were passing through the printer's hands, he was also occupied on a translation of all the works of Plato, with elaborately prepared arguments, in thirteen volumes; which was not

completed till 1840. A quarto volume of the previously unpublished writings of Abelard appeared under his editorial care in 1836, and three years afterwards he published his translation of Tennemann's Manual of the History of Philosophy.

These were only editorial labors expended upon the writings of others. The most important of his own philosophical works, many of which had previously passed through several editions, reappeared in a collected form in 1847, in twenty-two volumes. But his literary activity was not even then exhausted. Turning from philosophy proper to history and *belles-lettres*, he found amusement and occupation for his declining years in writing about a dozen volumes of biographical sketches and memoirs, illustrative of the state of French society and politics in the seventeenth century, and perhaps a score of miscellaneous publications, many of which first appeared in Reviews and other periodical collections. Separate notice should also be taken of his labors in the cause of public education; two elaborate and extensive reports, made by him, under government authority, on the state of primary and public school instruction, the one in Holland, and the other in Prussia and other portions of Germany, appeared in 1838 and 1840, and had considerable influence in modifying the school system not only in France, but here in America. On the whole, a busier and more productive life, and one more efficient in its action upon the opinions and conduct of men, could hardly be found anywhere in the annals of letters and philosophy.

Cousin visited Germany for the first time in 1817, and there became personally acquainted with Hegel, whose conversation and writings had a marked influence upon his subsequent speculations in philosophy; but after the revolution of 1848 he forsook and disavowed this school of pantheistic metaphysics. Then, also, after he had been for a quarter of a century a leader of the liberal and *doctrinaire* party in the long warfare between the University and the Church, he read his palinode, and joined heartily in the attempt made by his philosophical associates in the Institute to re-establish, by a series of brief popular treatises, the main doctrines of morality and religion, of order and law, in the minds of a deluded and exasperated populace. His contribution to this combined effort was a singular one; it was a republication of Rousseau's well-known "Savoyard Vicar's Confession of Truth," with notes and a brief preliminary treatise, both even more earnestly religious in tone than the text. It must have been edifying to the numerous students of the

philosophical doctrines which he had been expounding for so many years, to find him maintaining in these notes, in opposition to Rousseau, the doctrine of the efficacy of prayer. Another tract which he contributed to this remarkable series, entitled "Justice and Charity," contained a refutation of the doctrines of the Socialists. His former lectures on the True, the Beautiful, and the Good, were also republished by him in 1853, so materially amended and purified as to win for him the hearty applause of the most conservative party in the Church and the State. Indeed, it was only in the earliest portion of his career that Cousin espoused liberal opinions in politics with a zeal that lacked discretion.

In his second visit to Germany, in 1825, he was arrested by the police on suspicion of complicity in some Carbonari plots, and suffered an imprisonment of a few weeks at Berlin; and he profited by this enforced leisure to make a more thorough study of the Hegelian philosophy. He had been silenced as a lecturer by the Villèle ministry at home; but the triumph of the Martignac party in 1827 restored to him and his colleagues the exercise of their professorial functions. Then, as one of the illustrious triumvirate with Guizot and Villemain, he contributed his full share to that unparalleled triumph of letters, philosophy, and eloquence, which gave greater attraction and renown for a season to the lecture-rooms at the Sorbonne than belonged to any legislative or forensic assembly in Europe. A hall could not be found spacious enough to accommodate the immense crowd, representing all that was most distinguished in rank, fortune, and reputation in Paris, which flocked daily to hear three University Professors lecture upon philosophy, history, and literature. The sensation created was all the greater, as it had the aspect of a political triumph; and each speaker was vociferously applauded at the utterance of every remark which, whether so intended or not, could be construed into a political allusion. In fact, these three courses of lectures, delivered in 1828, were among the chief determining causes of the Revolution of 1830, and the peculiar character of the government by which it was succeeded.

The reputation of Cousin culminated at this epoch; never afterwards did he appear so original and ingenious as a thinker, or so polished and eloquent as a writer, as when stimulated by this great popular success. His lectures were immediately published, and showed both the excellences and defects of his manner. They are intensely French in conception, taste, and execution; they abound in

glittering generalities and perilous leaps in reasoning; and the rhetoric, though ornate, is too often declamatory; but they must be tried by the writer's national standard, and not by English principles of criticism. They were excellent in their kind, though inferior in depth and originality of thought, and in all the higher merits of philosophical disquisition, to the admirable lectures on history delivered at the same period by Guizot. The lectures of the following year, on the philosophy of the eighteenth century, though less popular, were really of a higher quality, more carefully studied, less rhetorical, richer in matter, more precise in statement, and more instructive in exposition and criticism. Regarded generally, they are Cousin's best work, his ablest contribution to the history of philosophy. Taken in connection with the course of the preceding year, they afford a satisfactory view, an interesting exposition and defence, of the writer's system of philosophy, so far at least as he could be said to have any system sufficiently original to be appropriately designated by his name. He was avowedly an eclectic; not professing to make discoveries, or to invent a theory of his own, he chose the humbler but more useful task of expounding and criticising the theories of predecessors, adopting some things and rejecting others, and thus piecing together out of selected fragments a body of coherent doctrine. From the Scotch philosophers, as represented by Reid and Stewart, he borrowed a method of inquiry, a theory of the foundation of morals, and a refutation of the sensualism and materialism that had been taught by Helvetius and Condillac. Among his countrymen, he was chiefly indebted to Maine de Biran, whom he followed implicitly in his theories of personality, of causation, and of the freedom of the will. From the Germans, especially from Schelling and Hegel, but with considerable modifications, he adopted his doctrines of the absolute, of the impersonality of reason, and of the *a priori* method of studying the necessary development of historical events. The principal result of Cousin's labors, therefore, may be said to be the reconciliation, and the general adoption in France, of the leading dogmas of the Scotch and German schools of philosophy.

To have the reputation of being a skilful expounder and critic of other people's opinions may not appear very flattering; yet such work ought not to be held in light esteem. To break up the distinctions between various schools, to harmonize doctrines which have been made to appear incongruous only because originally incorporated into rival

systems, and to give universal currency to the treasures of thought, learning, and taste, which had otherwise been confined to one language and people, is an office which has sure claims on the gratitude, though it may not challenge the admiration, of mankind. One cannot, even if he would, avoid incorporating into his own system some portion of the labors of others, whether these elements remain as they were when first announced, or have since passed out into the world as familiar principles of thought or conduct; and Cousin will probably be remembered by posterity, not as the founder of a new method or school, but as an able historian and critic of previous systems of metaphysics, and an eloquent expounder and teacher of many truths in philosophy which have long been the common heritage of mankind.

The accessions to our ranks during the past year have been unusually large, consisting of sixteen Resident and four Associate Fellows, and four Foreign Honorary Members.

In the Foreign Honorary Membership, Mr. Bentham, President of the Linnæan Society, replaces the late Professor Lindley.

M. Faye, of Paris, replaces Encke, of Berlin.

Professor Rankine, of Glasgow, was chosen in place of the late Admiral Smyth, and Henry Sumner Maine, in that of the late Dr. Whewell.

In conclusion, the Council submitted a nomination to fill the vacancy in the list of Foreign Honorary Members made by the decease of M. Cousin; also nominations to the list of Associate Fellows.

The Annual Report of the Treasurer was received, read, and ordered to be entered on the records.

Professor Lovering, as chairman of the Committee of Publication, presented the report of this Committee, accounting for expenditures in printing the Memoirs and Proceedings under the appropriations of the past year.

Professor Henck, as chairman of the Library Committee, presented the report on the condition of the Library.

A recommendation from this Committee to increase the salary of the Assistant Librarian, was referred to the Rumford Committee.

Professor Lovering presented a report from the Rumford

Committee, recommending an appropriation for the purchase of certain Journals and other publications. The report was accepted and 532 dollars were appropriated to the use recommended.

Mr. C. M. Warren made a brief report from the Committee to provide accommodations for the Academy.

Professor Eliot was excused from further service on this Committee, and Professor Cooke was appointed in his place.

Action on the appropriations recommended by the Treasurer was postponed to an adjourned meeting.

The following gentlemen were elected members of the Academy: —

Dr. C. Edward Brown-Séquard, to be a Resident Fellow in Class II. Section 3.

Commodore John Rodgers, U. S. N., to be a Resident Fellow in Class I. Section 4.

Dr. J. Lawrence Smith of Louisville, Kentucky, to be an Associate Fellow in Class I. Section 3.

Hon. Horace Binney of Philadelphia, to be an Associate Fellow in Class III. Section 1.

Hon. Daniel Lord of New York, to be an Associate Fellow in Class III. Section 1.

Major-General Sabine, President of the Royal Society, London, to be Foreign Honorary Member in Class II. Section 1, in place of the late Admiral Duperrey.

Nominations for election into the Academy were presented and read.

The annual election resulted in the choice of the following officers for the ensuing year: —

Asa Gray, *President.*
George T. Bigelow, *Vice-President.*
William B. Rogers, *Corresponding Secretary.*
Chauncey Wright, *Recording Secretary.*
John C. Lee, *Treasurer.*
Frank H. Storer, *Librarian.*

Council.

THOMAS HILL, JOSEPH LOVERING, JOHN B. HENCK,	of Class I.
LOUIS AGASSIZ, JEFFRIES WYMAN, CHARLES PICKERING,*	of Class II.
ROBERT C. WINTHROP, GEORGE E. ELLIS, ANDREW P. PEABODY,	of Class III.

Rumford Committee.

JOSEPH LOVERING, JOSEPH WINLOCK,
MORRILL WYMAN, WOLCOTT GIBBS,
WILLIAM B. ROGERS, JOSIAH P. COOKE,
FRANK H. STORER.

Committee of Finance.

ASA GRAY,
JOHN C. LEE, } *ex officio*, by statute.
THOMAS T. BOUVÉ, by election.

The other Standing Committees were appointed on the nomination of the President, as follows: —

Committee of Publication.

JOSEPH LOVERING, JEFFRIES WYMAN,
CHARLES W. ELIOT.

Committee on the Library.

JOHN B. HENCK, CHARLES PICKERING,
JOHN BACON.

Committee to audit the Treasurer's Accounts.

CHARLES E. WARE, CHARLES J. SPRAGUE.

* Elected at the adjourned meeting.

Five hundred and eighty-fourth Meeting.

June 11, 1867. — Adjourned Statute Meeting.

The President in the chair.

A portion of the Annual Report of the Council was read.

Professor Lovering reported from the Rumford Committee a recommendation that 200 dollars be paid by the Treasurer, from the Rumford Fund, to Dr. Francis Dana, for services as Assistant Treasurer during the ensuing year. The recommendation was adopted.

On the motion of Professor Lovering it was voted to renew the appropriation of 500 dollars, which was made last year to complete the publication of Dr. Storer's Memoir.

The following appropriations were voted: —

For General Expenses, from the General Fund .	$2,100
" " " from the Rumford Fund .	200
For Publication	1,100
For the Library	600

Dr. Charles Pickering was elected a member of the Council, to fill a vacancy left at the annual election.

The following paper was communicated: —

Characters of New Plants of California and Elsewhere, principally of those collected by H. N. Bolander in the State Geological Survey. By Asa Gray.

Ranunculus alismæfolius, Geyer, var. alismellus: pusillus; caulibus subscapiformibus spithamæis; foliis tenuioribus subovatis oblongisve (pollicaribus), petiolo sæpius gracillimo. — Lake Tenayo and on Mount Dana, Sierra Nevada, to the height of 12,000 feet, Bolander. With the aspect of *R. Flammula*, has the ovary and style of *R. alismæfolius.*

Ranunculus Andersonii: *R. glaciali* similis, sed calyce glaberrimo, ovariis semiorbiculatis compressis immarginatis stylo nudo subulato recurvato terminatis. Planta tripollicaris, aut tota glabra, aut basi dilatata petiolorum lobisque foliorum pilis albidis deciduis parce ciliatis. Flos pollicem diametro; petalis saturate roseis; sepalis margine rubellis. Segmenta foliorum petiolulata. — Near snow, on Blind Springs

Mountain in the Eastern Sierra Nevada, Dr. C. L. Anderson, 1866. The allied *R. Chamissonis* has the achenia winged, as much as *R. glacialis.*

RANUNCULUS (APHANOSTEMMA) HYSTRICULUS: glaber; radice fasciculata; foliis omnibus radicalibus reniformi-rotundatis 5-lobis crenato-lobulatisque; scapis folia superantibus nudis unifloris rariusve unifoliatis bifloris; sepalis (5–6) petaloideis albis ovalibus; petalis totidem staminibus brevioribus nectariformibus, ungue longo lamina parva ovali subcarnosa basi foveolata terminato; carpellis lanceolatis tenuiter membranaceis pilosciusculis stylo subrecurvo rostratis in capitulum subglobosum hystricinum arcte digestis. — Foot-hills of the Sierra Nevada, at Forest Hill and at New Castle, Placer Co., April, 1865, Bolander. Also, 1866, by Mr. Rattan, a state with longer petioles (6 inches long), and scapes nearly a foot high: apparently in wet soil. Sepals nearly half an inch long, deciduous. Petals inconspicuous, 1½ to 2 lines long, apparently yellow, gland-like, consisting of a minute fleshy lamina, with its base impressed with a nectariferous pit, raised on a claw of twice its length. Carpels 3 lines long when nearly full grown, remarkably slender and tapering, not striate nor margined. Ovule ascending as in *Ranunculus.* — Nothing like this has before been met with; but the characters, as to calyx and corolla, are those of St. Hilaire's *Aphanostemma,* although the subulate carpels very different; so that this accession, remarkable as it is, hardly tends toward the re-establishment of that genus.

AQUILEGIA CALIFORNICA, Lindl. in Gard. Chron. 1854, p. 836, & 1857, p. 382. *A. eximia,* Van Houtte, Fl. des Serres, Jan. 1857, cum ic. This is common in California (is Hartweg's, no. 1635), and comes also from Oregon. In cultivation the characters do appear to be well marked. That is, the sepals are reflexed; the spurs, scarcely longer than the sepals, are much thickened at the tip, and truncate at the mouth, the limb of the petals being extremely short. But Fischer's *A. formosa* is intermediate between this and *A. Canadensis* in the relative length of the spurs and sepals, the latter widely spreading. In cultivation *A. Californica* comes into flower a month later than *A. Canadensis.*

DRABA DOUGLASII: *Leucodraba;* caudice multicipiti; foliis omnibus rosulatis subcartilagineis fere eveniis integerrimis margine crebre hispido-ciliatis facie aut glabris aut cum scapo aphyllo corymboso-plurifloro hirsutulis (pilis omnibus simplicibus), imis ovatis, superiori-

bus obovatis spathulatisve; floribus majusculis albis; silicula ovata puberula stylo gracili superata, loculis sub apice biovulatis. — High Sierra Nevada; on the gravelly 'divide' between East Carson and West Walker Rivers, April, Dr. C. L. Anderson. I have a small fruiting specimen of this from Douglas's collection in the interior of Oregon or California; hence the name adopted for what appears to be a very distinct new species. In the firmness of the leaves, the size of the flowers, and the slender style (a line long and almost half the length of the silicle) this approaches the *Aizopsis* section, but is a genuine *Leucodraba.* Flowers as large as those of *D. ciliata:* sepals oval, glabrous, half the length of the bright white petals. *D. densifolia,* Nutt., as to the published character comes near to our species, but, from Nuttall's incomplete specimen kindly supplied by Mr. Durand, I take that to be a form or near relative of *D. glacialis,* with longish style. It is quite hirsute, even to the sepals, with 2 – 3-forked as well as some simple hairs, and the petals appear as if they were pale yellow: the cells of the ovary are 6-ovulate.

Lepidium dictyotum: annum, tenellum, undique puberulum; foliis angusto-linearibus integerrimis subgramineis; floribus (an semper?) apetalis tetrandis; siliculis subtiliter reticulatis subovatis apice subalato profunde emarginatis pedicello plano erecto longioribus. — Nevada, at Steamboat Springs, Horace Mann; and in most sage-bush lands, Dr. C. L. Anderson. Specimens only 3 inches high; the grassy leaves one or two inches long: racemes strict. Silicle 2 lines long, and with a deeper notch than in those of *L. lasiocarpum,* Nutt. (in which, moreover, they are widely spreading), also more puberulent and more evidently reticulated.

Cleomella obtusifolia (Torr. in Pl. Wright. 1, p. 12), char. suppletus: bracteis inferioribus trifoliolatis; stipulis in crines solutis; calycis lobis setoso-fimbriatis, seta terminali prælonga; stipite gracillimo, fructifero in pedicellum paullo longiorem refracto; stylo ovario bis longiori; capsula bicornuta; seminibus lævibus. — In sand, near Soda Lake, June 1, 1861, J. G. Cooper; branches, in flower and fruit. The scarious stipules are cut up into what appears to be a conspicuous tuft of bristles in the axil of the petiole; and the sepals are similarly but more sparingly crinite. Ovules 4 – 6 on each placenta. The capsule is more strongly lobed than in any other species, the back of each valve in well developed specimens being abruptly produced into a divergent horn (3 lines long, nearly as long as the style); when the

valve is detached it may be likened to a cornucopiæ with a very flaring mouth, holding 2 seeds.

SILENE BOLANDERI: multicaulis, nana, tomentulosa; caulibus 1–5-floris; foliis spathulatis acutis basi (summis exceptis) longe attenuatis; calyce oblongo-clavato haud viscoso, dentibus ovato-oblongis acutiusculis; petalis pallide roseis calyce duplo longioribus dentibus 2 minimis coronatis, ungue lato basim versus villoso-ciliato, lamina 4–6-partita, segmentis lanceolatis seu linearibus uno alterove nunc apice bifidis; ovario brevissime stipitato. — Wooded hillsides, Long Valley, Plumas Co., Bolander. Stems 3 to 5 inches high, many from a deep perpendicular root, leafy. Leaves 1½ to 2 inches long, including the tapering base or winged petiole. Peduncle of the primary flower an inch and a half long. Calyx-teeth 2 or 3 lines long. "A very showy" and distinct species.

SILENE INCOMPTA: viscoso-puberula; caulibus cæspitoso-aggregatis patulis (ultrapedalibus) foliosis thyrso laxifloro racemiformi vel paniculato terminatis; foliis oblongis seu ovali-lanceolatis acutis; pedicellis flore brevioribus; calyce cylindraceo (fructifero ovoideo vix semipollicari), dentibus lanceolatis tubo dimidio brevioribus; petalis albidis parvulis, lamina lineari-oblonga ungue apice utrinque unidentato vix latiori bifida, lobis nunc emarginatis vel bilobis, corona e dentibus subulatis. — Mount Bullion, and in the Yosemite Valley, in large tufts, Bolander. — Calyx sometimes purplish towards the base. Lamina of the petals only 3 lines long.

ACHYRONYCHIA, Torr. & Gray, nov. gen.

Calyx 5-fidus, persistens; tubo 10-nervi coriaceo demum cylindraceo; lobis mox radiato-patentibus ovalibus muticis præter basim calloso-incrassatam argenteo-scariosis enerviis. Petala nulla. Filamenta vel staminodia 15 fauci uniseriatim inserta, tenuia, subulata, unicum (rarissime 2?) antheriferum, cætera sterilia. Anthera didyma. Ovarium uniloculare, filo conductorio axili tenuissimo percursum: stylus brevis, bifidus. Ovula 2, basilaria, erecta, anatropa? funiculis brevibus. Utriculus tenuis, calycis tubo indurato inclusus, pyriformis, ovulo altero sterili superstite monospermus. Semen oblongo-pyriforme, facie recta rhaphi brevi cum chalaza longe infra medium notata. Embryo dorsalis, albuminis parci farinacei hinc applicitus, radicula elongata fere recta, cotyledonibus brevibus accumbenti-incurvis. — Herbula annua, depressa, *Paronychiæ* seu *Alternantheræ sessilis* facie;

foliis spathulatis oppositis, altero minore; stipulis majusculis hyalino-scariosis; floribus in axillis cymoso-congestis.

ACHYRONYCHIA COOPERI. — In dry sand, Mohave River at Camp Cady, Dr. J. G. Cooper, June, 1861. In Arizona or Sonora, A. B. Gray. — Stems spreading from the slender root, 2 or 3 inches long, glabrous, as is the whole plant. Leaves thickish and veinless, the larger of each pair from a quarter to half an inch long, its fellow barely half as large. Stipules interpetiolar, one on each side, orbicular or ovate, nearly entire, silvery-scarious. Flowers in dense subsessile clusters, bright silvery-white from the scarious calyx-lobes and stipular bracts, these lobes about half a line long, at first longer than the tubinate calyx-tube, which at maturity considerably exceeds them and becomes cylindraceous and thickened in the manner of *Scleranthus*. The firm texture and thickening of the tube extends into the axis of the broad and plane oval or orbicular lobes for nearly one third of their length, making a strong herbaceous, or at length more indurated, callosity in the base of each; all the rest is purely scarious, and without a vestige of midrib. The filaments are very short and delicate, with their broadish bases contiguous: if any arrangement can be traced it is, perhaps, that they are single before each calyx-lobe, and in pairs before each sinus. The fertile stamen is before a calyx-lobe; and one flower out of many examined apparently bore two anthers. The ovules appear to be truly anatropous, on very short funiculi. But in the seed the chalaza, as in *Pollichia*, is very much nearer the pointed hilar extremity, with which it is connected by a delicate short rhaphe; the seed is straight and somewhat edged on that side, rounded above on the other; the thinnish testa delicately lineate; the slender embryo nearly the length of the seed. The very thin utricle bursts irregularly, at least when the seed is extracted. — This curious little plant confirms the judgment of Bentham and Hooker in retaining *Pollichia* with *Paronychia* and its nearest allies, notwithstanding the geminate ovules. With the aspect somewhat of *Paronychia polygonifolia* and the like, and a calyx which *Siphonychia* somewhat resembles, this combines the geminate erect ovules, one fertile the other sterile, and the straight seed and straightish embryo of *Pollichia*. It is most peculiar in the remarkably silvery-scarious calyx-lobes, and in the numerous sterile filaments or staminodia. To separate entirely from the *Caryophyllaceæ* these plants, along with *Scleranthus* and the other exstipulate genera, while leaving *Queria*, *Sphærocoma*, and the *Polycarpeæ* generally, requires narrow and devious, and probably at length impracticable distinctions.

Talinum pygmæum (Gray, in Rep. Exped. Bryan, ined. & in Sill. Jour. 33, p. 407): foliis linearibus scapisque unifloris (nunc 2 – 3-floris) 1 – 2-pollicaribus e radice crasso confertis; sepalis orbiculatis glanduloso-dentatis; petalis roseis purpureisve; staminibus 6; stigmatibus 3 – 5. — Rocky Mountains, H. Engelmann, Dr. Parry, &c.; Cascade Mountains, Washington Terr., alt. 7,500, Dr. Lyall; and now collected in the Sierra Nevada, California, by Bolander. The thick caudex or root is rather fusiform in most specimens, in Bolander's it is napiform. Ovules numerous. Seeds as in the genus.

Sidalcea vitifolia: hirsuto-pubescens; caule valido elato ramoso folioso; foliis cordato-quinquelobis, lobis brevibus crenato-dentatis subincisis; spicis brevibus capitulisve densifloris brevipedunculatis subcorymbosis; calycis nudi lobis deltoideis acutatis; petalis albis obcordatis; phalangibus indistinctis; coccis muticis lævibus. — Bear Harbor, Mendocino Co., Bolander. Plant "from 3 to 6 feet high, in tufts," the upper part or branches leafy; the branchlets terminated by short and dense spikes or heads of one or two inches in length. Stipules subulate, caducous. Leaves 2 – 4 inches in diameter, beset especially beneath and on the petioles, as also the branches, with a short and roughish stellate pubescence. Pedicels extremely short, subtended by a filiform bract, which is often 2-cleft or toothed at the apex and deciduous: bractlets none. Calyx very slightly or sparsely hirsute, 3 – 4 lines long, cleft to the middle. Corolla 6 lines long, apparently white; the petals rather narrow. Stamens of the exterior series closely approximate to the inner, consisting of 10 narrow and 2-cleft biantheriferous filaments, i. e. each fork bearing a single anther; the inner set of about as many anthers, on mostly uncombined filaments. Branches of the style and carpels 9 or 10, the latter reniform, torn open on the ventral face as they separate from the axis. This new species, so unlike the rest of the genus in appearance, is closely related to

Sidalcea malachroides (*Malva malachroides*, Hook. & Arn.); hispida, gracilior; foliis cordato-rotundis sublobatis crenato-incisis; calyce setoso-hispidissimo 2 – 3-bracteolato (bracteolis setaceis deciduis), lobis triangulari-lanceolatis: cæt. fere præcedentis. — The two series of stamens, the exterior of 20 in pairs, I had not before detected in this rare plant. The fruit not yet seen. In a fragment of a fertile plant collected by Dr. Andrews the column is truncate and without a single anther in all the flowers; while in Douglas and Coulter's specimens, with good anthers, the ovules are apparently good. The anthers,

if not wanting, are deciduous from the column in some flowers of *S. vitifolia*, as in some cultivated specimens of *S. malvæflora*.

MALVASTRUM ROTUNDIFOLIUM: annuum, hispidum; caule erecto; foliis subreniformi-rotundatis grossius crenatis indivisis; pedunculis gracilibus folia plerumque superantibus; bracteolis angustissime linearibus calycis segmentis sensim acuminatis paullo brevioribus; petalis roseo-purpureis basi macula rubra; carpellis ultra 40 orbiculatis muticis reticulatis. — Sand hills at Fort Mohave (along with *M. exile*, Gray), Dr. J. G. Cooper. — In aspect not unlike some South American species, but more after the fashion of a *Sidalcea* than any of our species. The stigmas, however, are capitate, and the filaments not clustered. Plant rather sparsely, or the calyx more densely, hispid with simple or fascicled bristly spreading hairs. Leaves somewhat resembling those of *Malva rotundifolia*. Stem "two feet," or in depauperate specimens barely a span high. Calyx deeply 5-cleft. Corolla 1½ inches broad, apparently showy.

LINUM SPERGULINUM: annuum, fere glaberrimum; caule tenui (subpedali) superne effuse paniculato; pedicellis omnibus filiformibus flore multo longioribus mox patentissimis; foliis sparsis filiformibus; glandulis stipularibus nullis; sepalis ovalibus obtusis margine minutim glandulosis; petalis roseis albisve, ungue ima basi utrinque unidentato intus appendice linguæformi aucto; sinubus inter stamina obsolete crenulato-bidentatis; antheris oblongis; stylis 3; stigmatibus parvis. — Hills at Cloverdale, Sonoma Co., June, Bolander. Glabrous throughout, except a minute and sparse pubescence on some of the branchlets and pedicels, 6 – 12 inches high; the flowering branches more paniculate and much more effuse than those of *L. Californicum*, and with flowers only about half the size, all on almost setaceous, naked, and at length mostly declined pedicels of 4 – 6 lines in length. Sepals barely 1½ lines long. Petals 2 lines long, obovate, with a narrow claw, its ovate or oblong appendage adnate to its front, more conspicuous than that of *L. Californicum*. This and the following are interesting additions to the section *Hesperolinon* which was indicated in a former paper (6, p. 521) upon three Californian species; but these accessions require some modification of subsidiary characters; — this one, for instance, in the length of the pedicels and the very diffuse inflorescence.

LINUM MICRANTHUM: annuum; caule gracili superne aperte paniculato; ramis cum pedicellis calyce sæpius longioribus quandoque puberulis; foliis alternis angusto-linearibus; glandulis stipularibus

minimis; sepalis oblongis obtusiusculis vix ciliolato-glandulosis: petalis albis basi utrinque subunidentatis; sinubus inter stamina dente brevissimo glandulæformi instructis; stylis 3; stigmatibus subclavatis recurvis. — On Mount Bullion, Mariposa Co., Bolander. About a foot high. Flowers as much smaller than in the preceding as those are than in *L. Californicum*, even smaller than in *L. Virginianum* and *L. striatum*, Walt. (*L. oppositifolium*, Engelm.). This differs from the four other trigynous species now known, in wanting the little appendage to the face of the claw of the petal, and the lateral teeth are less distinct. The three false partitions of the globular capsule are almost complete. (In the old *Linum trigynum* of our conservatories I can no more find even a trace of appendages to the petals in fresh flowers, than could Bentham and Hooker in dried specimens. So far as regards this species the genus *Reinwardtia* has no characters.

LINUM DIGYNUM: annuum, glabrum; caule exili (spithamæo) apice subcymoso-plurifloro; foliis oppositis oblongis (lin. 3 – 6 longis); glandulis stipularibus nullis; pedicellis strictis calyce brevioribus; sepalis oblongo-lanceolatis obtusis uninerviis margine lacerato-denticulatis glandulosisque; petalis flavis; dentibus inter stamina nullis; stylis 2 liberis; stigmatibus capitatis; capsula quadrilocellata. — Mariposa Trail, Yosemite Valley, rare, Bolander. — Flowers small, but rather larger than in the foregoing. Petals not appendaged at the base. While all the other peculiar Californian species are trigynous, this is digynous!

LUPINUS BREWERI: fruticulosus, ramosissimus, cæspitoso-humifusus, pube appressissima argenteo-sericeis; stipulis subulatis; foliolis 7 – 10 spathulatis cuneatisve retusis (lin. 3 – 4 longis); racemo brevi (pollicari) densifloro; calycis bracteolati labio superiore bipartito; corolla violaceo; carina vix ciliata. — "Prostrate, trailing on the ground or on rocks, on the Yosemite trail, alt. 6,000 feet," Prof. Brewer. Nevada near Carson, Dr. C. L. Anderson; a form with flowers only 3 lines long, the keel not in the least ciliate; while in Prof. Brewer's specimens the flowers are 4 or 4½ lines long, and with a few hairs on the margins of the keel. — This ranks with the andine species forming Agardh's tribe *Microphylli*.

LUPINUS LYALLI: fruticuloso-cæspitosus, nanus, hirsuto-sericeus: stipulis subulatis; foliolis 5 – 6 obovato-oblongis (lin. 3-longis); pedunculo scapiformi nudo bipollicari capitulum multiflorum gerente; calycis bracteolati labio inferiore tridentato, superiore bipartito; corolla

(ut videtur) saturate cærulea, carina nuda. — Summit of the Cascade Mountains, lat. 49°, Dr. Lyall (Coll. Oregon Bound. Comm., distrib. Herb. Kew.). — The short, tufted shoots spring from a woody base barely an inch high, terminated by the solitary naked peduncle, bearing a head (half or two thirds of an inch in diameter) of deep blue or violet flowers. Pedicels short: bracts shorter than the calyx, caducous.

Lupinus Danaus: herbaceus, e caudice perenni cæspitosus, pumilus, strigoso-hirsutulus; stipulis subulatis; foliolis 4 – 5 oblanceolatis (lin. 2 – 4 longis); racemo oblongo (pollicari) densifloro; calycis minute bracteolati labio inferiore tridentato, superiore profunde bifido; corolla albo-violacea, carina rectiuscula ciliata. — Mount Dana, alt. about 12,500 feet, Bolander. — This interesting little Lupine may be held to bear the name either of the lofty peak it inhabits, or of the distinguished geologist and naturalist whom the mountain commemorates. It was very scantily collected, and is probably rare or out of reach. The slender and diffuse or ascending flowering stems are only 2 or 3 inches high, and 1 – 3-leaved below the middle. Bracts subulate, rather shorter than the calyx, twice the length of the pedicel. Corolla 3 lines long; the vexillum and wings apparently white and tinged with blue or violet, the keel deep violet. — This and the two preceding seem very distinct from all other North American species. Neither of them can well be *L. minimus*, Dougl., which I do not identify.

Trifolium Bolanderi: *T. repenti* subsimile, multiceps e caudice incrassato, glaberrimum; caulibus adsurgentibus 1 – 2-floris; stipulis herbaceis; foliolis obovato-oblongis vix retusis; pedunculis (spithamæis) folia longe superantibus; floribus (cærulescentibus?) arcte capitatis mox deflexis; pedicellis etiam fructiferis brevissimis; calycis dentibus subulatis tubo campanulato basi gibboso subæquilongis; ovario dispermo. — Westfall's Meadows above the Yosemite Valley, at the elevation of 8,000 feet, Bolander.

Trifolium barbigerum (Torr. Bot. Whippl. Exped.), var. Andrewsii: multo majus, subpedale, villosum; foliolis majoribus subpollicaribus; involucro explanato quandoque fere pollicem lato (corollis atropurpureis). — Collected by the late Dr. Andrews in 1856; but now Mr. Bolander sends it from Mendocino City (4781), with heads &c. fully as large as those of the related *T. cyathiferum*, and also, from drier and sandy soil (4755), in a form like the original of Bigelow and Fitch, but less depauperate.

Dalea divaricata, Benth. Bot. Voy. Sulph., var. cinerea: pube

minuta præsertim calycis albescens; pedunculis haud divaricatis bi-tripollicaribus; spicis virgatis laxe 25-40-floris; calycis dentibus ovato-oblongis, infimo paullo longiore. — Fort Mohave, on gravelly hills, Dr. J. G. Cooper. "Stems two or three feet high: flowers dark purple." Except for the minute hoary pubescence and other minor particulars, this would seem to be Bentham's *D. divaricata*, from the coast of Lower California (and a comparison of specimens made at Kew discloses no specific differences). There is nothing divaricate in the specimens, however.

Petalostemon foliosus: undique glaber; caulibus crebre foliosis; foliolis 8-14- (sæpius 12-) jugis lineari-oblongis mucrone cuspidatis, glandulis paucis parvis; spica cylindrica brevi-pedunculata; bracteis aristatis e basi lanceolata; calycis dentibus subæqualibus tubo cylindraceo dimidio brevioribus; floribus roseo-purpureis. — Banks of Fox River, Kane Co., Illinois, Burgess Truesdell, 1867. Also near Nashville, Tennessee, Mr. Hatch, 1854. A well-marked species, which has been singularly overlooked, or else is very local. It has the habit of *P. villosus*, but with yet more numerous leaflets, and is glabrous throughout, even to the ovary. The very numerous and equable leaflets, thicker spikes with more exserted bracts, shorter calyx-teeth, &c., no less than the color of the flowers, distinguish it at once from *P. candidus*. Both ovules are apt to be fertile in this and the last-named species.

Astragalus malacus: undique molliter villosus; caulibus e caudice perenni gracili erectis 2-3-foliatis (spithamæis vel pedalibus); foliolis 6-7-jugis obovatis retusis; pedunculis folia superantibus spicam multifloram demum laxifloram gerentibus; calycis tubo cylindrico dentibus setaceo-subulatis triplo longioribus; corolla læte purpurea; legumine oblongo-lanceolato arcuato haud stipitato crebre mollissime villoso tenuiter coriaceo subcompresso sutura dorsali (extus leviter sulcata) usque ad ventralem acute marginatam intrusa bilocellato polyspermo (sectione transversa auguste obcordata). — Nevada, near Carson City, Dr. C. L. Anderson. I formerly confounded an imperfect specimen of this with *A. Parryi*, Gray; and I know of no other more nearly related to it. But it is more softly villous, and usually more caulescent, has far longer peduncles, and spikes of bright purple or violet flowers, in a raceme which at length elongates, often to the length of 4 inches, the tube of the calyx is longer and narrower (flower over half an inch long); and the very villous legumes are thinner,

little over an inch in length, and when apparently mature not at all obcompressed but somewhat flattened laterally, with the acute ventral suture salient, completely bilocellate.

Astragalus Arthu-Schottii, Gray, Rev. Astr., char. fruct. emend.: spithamæus ad tripedalem; legumine maturo ovato acuminato (lin. 7 – 8 longo) canescente chartaceo ad suturam ventralem profundius sulcato ob septum dorsalem completum bilocellato. — In sand on the Mohave River, at Camp Cady and elsewhere, Dr. J. G. Cooper.

Astragalus Bolanderi: subpedalis, cinereo-puberulus; stipulis brevibus scariosis adversus petiolum connatis; foliolis 6 – 9-jugis sublinearibus oblongisque; pedunculis folio brevioribus capitato-plurifloris; pedicellis brevissimis, fructiferis reflexis; legumine in stipitem e calyce exsertum hamato-incurvo ovato acutato obcompresso turgido coriaceo glabro (lin. 8 – 9 longo 3 – 4 lato) polyspermo ob septum completum bilocellato. — Dry ground, at Ostrander's Ranch, Yosemite Valley, Bolander. Flowers not seen. The teeth of the calyx are almost setaceous, and more than half the length of the cylindraceous tube. Stipe 4 lines long. The species is to be ranked, perhaps, with the *Oroboidei*, although the stipules are connate and the legume completely two-celled.

Lathyrus Torreyi: pusillus (spithamæus ad pedalem), villoso-pubescens; radice perenni; stipulis semisagittatis angustis; foliolis 4 – 6-jugis ovalibus mucronatis (lin. 4 – 8-longis); cirrho simplici sæpius brevissimo; pedunculo brevi vel brevissimo sæpius unifloro; calycis lobis setaceo-subulatis tubo duplo longioribus; corolla purpurascente; legumine pauci-ovulato monospermo in pedicellum deflexo. *L.? villosus*, Torr. in Stevens (Cooper & Suckley) Pacif. R. R. Rep.; a preoccupied name. — Mendocino or south part of Humboldt Co., Bolander. A neat and peculiar little species, very different from any other, at least in North America, in slenderness, in the small size of the leaflets, and the single-flowered peduncles. The latter are sometimes scarcely longer than the stipules, and seldom half the length of the leaf. Bolander's specimens are past the flowering state; the young legume minutely pubescent, semi-oblong, flat, apparently maturing only a single seed.

Prunus (Amygdalus) Andersonii: glaberrima; ramis spinescentibus; foliis fasciculatis parvis (lin. 4 – 9 longis) spathulatis oblongisve obtusis tenuiter subnervoso-venosis subserrulatis eglandulosis; floribus longiuscule pedicellatis; calycis (ebracteolati) lobis integer-

rimis tubo turbinato brevioribus; petalis læte roseis; ovario cum styli basi hirsutissimo; drupa sicca subglobosa pubera. — Foot-hills of the eastern side of the Sierra Nevada, near Carson: fl. March, Dr. C. L. Anderson. [Also collected by Dr. Torrey.] "About 3 feet high." Flowers showy; the petals apparently of nearly the color of peach-blossoms, 4 lines long, entire. Lobes of the calyx broadly triangular and obtuse, at length oblong. Stamens as long as the petals, 25, tri-seriate, but approximate. Drupe half an inch long.

HORKELIA BOLANDERI: humilis, cæspitosa? vel humifusa e caudice lignescente; foliis pube molli densa villoso-incanis; foliolis 13 – 21 cuneatis palmatifidis, lobis 3 – 5 ovatis oblongisve; stipulis angusto-linearibus integerrimis; cyma parva densiflora; calycis alte 5-fidi segmentis accessoriis oblongis quam vera latiora subdimidio brevioribus; petalis obovatis vix unguiculatis; filamentis lanceolatis. — Dry alkaline soil, near Clear Lake, coll. January, 1863, Bolander. Only winter specimens known; the flowering stems rising 3 to 5 inches above the lignescent and tufted leafy base. This and the following are among those species which go far to justify the views of Bentham and Hooker, and now also of Engelmann, who would combine *Horkelia* and *Ivesia* with *Potentilla.* I am reluctant to adopt this conclusion, but have chosen a specific name which is not preoccupied in the latter great genus.

IVESIA TRIDENTATA (*Horkelia tridentata*, Torr. Bot. Whippl. t. 6): pube mollissima villosa; caulibus patentibus vel erectis (pedalibus) gracilibus apice nudis; foliis junioribus argenteo-sericeis, adultis subglabratis; foliolis 5 – 11 subdissitis oblongo-cuneatis apice plerumque tridentatis; stipulis pauci-laciniatis vel subintegris; cymis pedunculatis confertifloris; pedicellis evolutis florem adæquantibus; calycis campanulati segmentis accessoriis linearibus tubo æquilongis quam vera acutissima brevioribus; petalis (albis) breviter unguiculatis; staminibus 10; carpellis 5 – 10? — In the Sierra Nevada. The character is here drawn up from the very beautiful and complete specimens collected by Mr. Bolander, in 1866, in the region near Mount Dana. The stems are about a foot high and erect or nearly so. Leaflets of the earlier radical leaves inclining to obovate, of the stem-leaves (reduced to 1 – 3 pairs) verging to linear-cuneate: some of the upper stipules entire. The narrow filaments are adnate to the calyx-tube up to the sinuses and base of the lobes, and are thus distant from the (villous) receptacle, as in *Horkelia* and *Ivesia* generally, but not in

Potentilla. Carpels in these specimens usually 5. I have not found so many as 10; although Dr. Torrey's figure represents a larger number, and also omits the villosity of the receptacle. This species is certainly embarrassing to the maintenance of these genera; but it ranks with *Ivesia*, although the foliage is anomalous.

Ivesia unguiculata: laxe villosa, subpedalis; foliolis perplurimis quasi-verticillatis laxis plerisque bis-bipartitis, segmentis linearibus; stipulis pauci-laciniatis vel integris; floribus glomeratis; pedicellis brevissimis; calycis segmentis accessoriis linearibus vera triangulari-lanceolata acutissima fere adæquantibus; petalis dilatato-cuneatis longe tenuiter unguiculatis; staminibus sub-15, filamentis filiformi-subulatis; carpellis 5 – 8. — Westfall's Meadows, Yosemite Valley, alt. 8,000 feet, in wet places, Bolander. Stems in tufts from a thickish caudex, from a span to a foot high. Leaves in aspect not unlike those of *Horkelia tenuiloba*, but the leaflets crowded much like those of *Ivesia Gordoni*, and whitish-silky or villous with long very soft hairs when young, but glabrate with age. The leaflets are 2 or 3 lines long, more commonly twice 2-parted into linear or linear-spatulate divisions, some of them simply 3-parted, others 2-parted, and the divisions cuneate and 2-cleft. Stipules lanceolate, acuminate and nearly entire, or broader and cut into 2 or 3 lanceolate lobes. Cymes or dense clusters short-peduncled. Calyx 3 lines long, deeply cleft. Petals 2 lines long, the slender claw more than half the length of the broadly cuneate-obovate lamina. Stamens shorter than the calyx, one inserted before each petal and one each side of it, i. e. two to each true calyx-lobe, not before its centre but lateral. The arrangement is, perhaps, more clearly expressed by saying that, when 15, ten are alternate with the ten calyx-lobes, counting the accessory ones, and five are opposite the latter. These five appear to be always present; but one or two, or even three or four, of the ten are occasionally wanting. Receptacle sparingly villous.

Ivesia santolinoides (Gray, Proceed. Amer. Acad. 6, p. 531), char. suppl.: spithamæa ad pedalem; cyma demum effusa ramossissima, ramulis pedicellisque capillaribus; achenio subreniformi-globoso utriculato calycem fructiferum implente. — From fine fruiting specimens gathered by Bolander, on dry rocky hills along the Merced River, above the Yosemite Valley, alt. 9,000 feet. The inflorescence becomes paniculate, exceedingly effuse and decompound, and the pedicels generally from a quarter to half an inch in length. Petals orbicular, sessile.

Stamens 15, one before each true calyx-lobe, and two before each petal: filaments very capillary and as long as the calyx. Carpel only one, gibbous, with a sublateral style, in fruit the coriaceous-utricular achenium rising out of the cyathiform base of the calyx, and enclosed by its conniving lobes. Cotyledons plano-convex, the short radicle oblique, pointing to the base of the style. — It is really going too far to rank this plant under *Potentilla*.

POTERIUM OFFICINALE (*Sanguisorba officinalis*, L.), in a depauperate form, was collected by Mr. Bolander on the Mendocino Plains, in 1864: new to this continent.

GAYOPHYTUM STRICTUM: pube molli cinereum; caule (demum pedali) simplicissimo vel inferne parce ramoso rigido, a basi ad apicem in axillis foliorum angusto-linearum crebre florifero; petalis (incarnatis) oblongis bifidis calyce longioribus; antheris stam. breviorum polliniferis; stigmate subclavato breviter bifido; capsulis arcte sessilibus arrectis lineari-subulatis quadricostatis folia subæquantibus; seminibus in quoque loculo biseriatis ovalibus planoconvexis. — Dry hills, Cloverdale, Sonoma Co., Bolander. Petals 1½, and capsules 5 or 6 lines long. My original specimen of *G. cæsium* is too imperfect for verifying the published characters; but the present plant seems to differ sufficiently in its strict and rigid habit, and closely sessile appressed pods with a tapering point and much thicker valves, as well as in the stamens and stigma; and the seeds are more than double the size. The plant is stouter than any other *Gayophytum;* but the ovary is only 2-celled, although the ovules are in four ranks.

ŒNOTHERA (GODETIA) WHITNEYI: minute puberula; caule valido usque ad apicem crebre foliato; foliis oblongo-lanceolatis subintegerrimis; floribus confertis maximis; calycis tubo obconico segmentis multo breviore; antheris linearibus; stigmatibus linearibus elongatis; capsulis sessilibus (nunc subsessilibus) fusiformi-oblongis hirsuto-canescentibus (8 – 12 lin longis), loculis polyspermis; seminibus adscendentibus. — Plains at Shelter Cove, Humboldt Co.: "very striking and ornamental," Bolander. Stem about a foot high, simple. Leaves 1 or 2 inches long, tapering to both ends. Calyx-lobes fully an inch long. Petals fully 2 inches long, pink-purple, sometimes apparently with a crimson spot about the middle. Stigmas 3 lines long. The most splendid of all the *Godetias*, and very desirable for cultivation, from the fine color and great size of the flowers, crowded at the summit of the stem. In habit and in the capsule it is allied to *Œ purpurea*, &c.;

but the stigmas are long and yellow. The species is named for Prof. Whitney, the distinguished head of the State Geological Survey, in the prosecution of which it was discovered.

BOLANDRA, nov. gen. *Saxifragearum.*

Calyx campanulatus, dilatatus, ultra ovarium liberum longe productus, 5-fidus, lobis triangulari-lanceolatis acuminatis recurvis æstivatione valvatis. Petala 5, fauci calycis inserta, subulato-attenuata, recurva, persistentia. Stamina 5, petalis alterna, iisdem breviora: antheræ cordato-bilobæ. Ovarium ovatum, basi lata sessile, inferne biloculare multiovulatum, superne longe bifidum, cornubus æqualibus intus mox apertis stigmate truncato terminatis. Styli proprii vix ulli. — Herba glabella, parvula, caulibus e radice granulato-bulbillifera gracilibus alternifoliis, foliis (subreniformibus 5-lobis) *Saxifragæ* vel *Boykiniæ*, calyce *Tellimæ*, petalis *Tolmieæ* seu *Tiarellæ* sed majoribus firmioribus purpureo-viridulis calycis lobos subsimulantibus, carpellis mox hiantibus *Tiarellæ*, sed æqualibus stylo fere destitutis basi in ovarium biloculare *Saxifragæ* modo connatis. Flores majusculi, laxe subcorymbosi, longius pedicellati. Fructus maturus deest.

Bolandra Californica. — Yosemite Valley, on the Mariposa Trail, among rocks, July, H. N. Bolander. [Also coll. by Dr. Torrey, on foot-hills of the Sierra Nevada.) A span to near a foot high; the stems weak and slender. Leaves thin; the radical and lowest cauline round-reniform, about 5-lobed to near the middle, the broadish lobes somewhat 2 – 3-lobed or crenate-incised, on long petioles which are slightly dilated at the base; or the lower cauline with a dilated and clasping appendage at the base, resembling a pair of foliaceous adnate stipules: the upper leaves, wanting the petiole, pass from panduriform or cordate-clasping into ovate or oblong partly clasping bracts. Calyx-tube 3 lines long, very much broader than the included ovary, greenish, or the attenuate-pointed lobes, like the still more attenuate and longer petals, tinged with purple. Anthers emarginate at the top; the short cells not confluent. The subulate-conical beaks or summits of the ovary are hollow nearly to the stigma, but ovuliferous only below the junction: above, the ventral suture opens early. — For the last few years no one has done so much as Mr. Bolander for developing the botany of his adopted State, and perhaps no one is likely to do so much hereafter. It is with great pleasure that I find among his own discoveries a modest but very interesting plant, inhabitant of the far-famed Yosemite

valley, which, being a new generic type in a favorite order, may most appropriately and deservedly bear Mr. Bolander's name and commemorate his services to our science. In applying this name to species, as I have occasion largely to do, I have reluctantly followed the example set for me by Mr. Lesquereux and Professor Tuckerman, in writing "*Bolanderi*"; yet for the genus (notwithstanding the name is doubtless Scandinavian) I prefer the form consecrated by unbroken usage in the strictly similar case of Solander (also of Dryander, if that is not a genuine Greek-made name), and here write *Bolandra* rather than *Bolandera.*

SEDUM OBTUSATUM: glabrum, subglaucum; foliis planis spathulatis cuneatisve, summis oblongis; floribus laxe cymosis pedicellatis 5-meris; petalis ovali-oblongis "flavidis" sepala ovata longius superantibus, utrisque obtusissimis; seminibus appendice cultriformi terminatis. — Granite rocks in the Sierra Nevada, on Mount Hoffman and above Sonora Pass, Brewer; at Vernal Fall in the Yosemite Valley, Bolander. Habit and aspect of *S. spathulifolium* and *S. Oreganum;* but the flowers larger than in the former, all pedicellate, and petals paler, in the specimens mostly seeming to have been almost white.

DEWEYA, Torr. & Gray, Fl. N. Am. 1, p. 641. This genus, which Bentham and Hooker have recently, with *Velæa*, reduced to *Arracacia*, may be sustained upon the undivided carpophore and the total want of stylopodia; perhaps also on the completely involute seed. There is, indeed, no decisive evidence as to the carpophore in the original species, of which fully ripe fruit has not yet been examined, but it remains quite entire after the fall of the carpels in the two species now added. It is to be noted, however, that Bentham, in Pl. Hartw. p. 187, describes *Arracacia glaucescens* as having "carpophorum vix apice bifidum"; but this is passed over in the Genera Plantarum, where much is made of the carpophore in this tribe.

DEWEYA ARGUTA, Torr. & Gray, l. c.; Torr. in Bot. Mex. Bound. t. 26. — Folia simpliciter pinnata. Calycis dentes subulati persistentes. Fructus oblongus, jugis subalato-elevatis.

DEWEYA HARTWEGI: fere acaulis, secus petiolos venas venulasque foliorum scabrella; foliis biternatis et quinatis; foliolis obovatis seu ovali-oblongis quam *D. argutæ* minus argutis magisque confluentibus; calycis dentibus obsoletis; fructus paululum brevioris jugis carinato-elevatis vix alæformibus. — On the Sacramento, Hartweg, No. 1748, in flower. Near San Francisco, Dr. A. Kellogg, in fruit. A leaf

and single umbel of mature fruit, sent by Dr. Kellogg, enable me to confirm the suggested near relationship of this plant with *D. arguta*, with which it closely agrees except in the particulars indicated. The leaves have the stouter petiole first ternate, their divisions again ternate and bearing mostly 3 leaflets on the lateral divisions and 5 on the middle one, or else the lateral primary divisions are simply 5–7-foliolate. Fruit barely 3 lines long, laterally contracted, the salient ribs not so wing-like as in *D. arguta*, but otherwise similar. The broad intervals contain 2 or 3 vittæ. The mature seed is so involute that the cross section is circular and the albumen completely encloses a central cavity. This is also the case in *Conium* and *Smyrnium* when fully ripe. Carpophore wholly entire.

DEWEYA KELLOGII: acaulis, subpedalis; foliis triternatis; foliolis parvulis 3–5-fidis, segmentis cuneatis versus apicem argute dentatis incisisque, dentibus cuspidatis; umbella in scapo simplici solitario, involucellis e bracteis parvis subulatis; calycis dentibus obsoletis; fructu didymo (lin. 2 longo et lato); mericarpiis turgidis; jugis filiformibus, lateralibus commissuram angustam marginantibus; valleculis bivittatis. — Bolinas Bay, near San Francisco, June 23, with mature fruit, Dr. A. Kellogg. Caudex or root tuberous-thickened (as probably in both the preceding), its branches sending up a tuft of leaves about a span high, and a mostly taller naked scape. Involucre none. Rays of the umbel one or two inches, of the umbellets 2 or 3 lines long. Styles capillary. Fruit smooth. Carpophore entire, or only minutely cleft at the apex. Mature seed circular in cross section, with a large central cavity. [As this sheet passes to press I find that I have a flowering specimen, which was collected by Mr. Bolander, on Mission Hills, near San Francisco: scape 1-leaved below; flowers yellow.] Doubtfully referred to *Deweya*, but of widely different genus, is

OREOSCIADIUM ACAULE = *Deweya? acaulis*, Torr. Bot. Whippl. Exped. Pacif. R. R. Survey, 4, p. (94) 38. As to the fruit a clear congener of *O. montanum*, Wedd., but with conspicuous calyx-teeth.

APIUM (AMMOSELINUM) POPEI = *Ammoselinum Popei*, Torr. & Gray in Pacif. R. R. Surv. 2, p. 165. C. Wright collected this in Texas, in 1851; but it is in Berlandier's collection of 1828, No. 1789. The carpophore is not 2-parted, as described, but merely 2-toothed at the apex; and the plant will range near *Leptocaulis* and *Helosciadium leptophyllum*, except for the longer fruit and the corky development of the lateral ribs filling the commissure.

CARUM GAIRDNERI (*Atænia Gairdneri*, Hook. & Arn., & *Edosmia montana*, *prœalta*, & *Oregana*, Nutt.): var. LATIFOLIA: caule sesquipedali; segmentis foliorum 3 – 9 lanceolatis (ad semipollicem usque latis). — Sierras, Ebbett's Pass, Yosemite, and near Carson City, Brewer, Bolander, Dr. C. L. Anderson.

CARUM KELLOGII: glaber; radicibus fasciculatis sæpius fusiformiseu tuberoso-incrassatis; caule 2 – 4-pedali; foliis 2 – 3-ternatis vel 1 – 2-ternatis et pinnato-5 – 7-foliolatis, superioribus decrescentibus 7 – 1-foliolatis, petiolo communi spathaceo sublineari, foliolis linearibus utrinque attenuatis integerrimis summisve fere filiformibus; involucro aut abortivo 1 – 3-bracteato, aut perfecto e bracteis 5 – 9 lineari- seu lanceolato-subulatis iis involucellorum similibus; pedicellis brevibus; fructu leviter obovato stylopodiis magnis conicis calycisque dentibus subulatis conspicuis coronato, jugis inconspicuis impressis. — California near the coast: San Jose, Brewer (832); Oakland, Bolander; Bolinas, Dr. Kellogg. [Also collected, I find, by Fremont, in 1846, only in flower, but with thick farinaceous roots, as in *C. Gairdneri*.] According to Dr. Kellogg the plant is known as "Wild Anise," and the fruit yields a pleasant anisate odor. It is "very common," but being "about the latest flowering plant on the Oakland hills," according to Bolander, has escaped observation. The fully mature fruit, which I have only from Bolander, is twice or thrice as large as in *C. Gairdneri* (2 – 2½ lines long), tumid, the very large single vittæ filling the intervals, and so turgid that the jugæ are sunken, and the albumen under each sulcate. Calyx-teeth often half a line or more in length. Involucre and involucels when well developed conspicuous, rather membranaceous or scarious, and very much as in *C. Bulbocastanum*. The plant is, I presume, a congener of the preceding, which has been well reduced to a mere section of *Carum* by Bentham and Hooker, and is not to be widely separated from *C. Bulbocastanum*, notwithstanding the different root and the calyx-teeth, which in this species are especially conspicuous.

CICUTA CALIFORNICA: foliis inferioribus tantum bipinnatis, superioribus sæpe simpliciter pinnatis 5 – 7-foliolatis; foliolis ovato-lanceolatis, venis primariis tenuibus in dentes desinentibus; involucro vix ullo; fructus jugis contiguis subæqualibus vittas (in valleculis lateralibus nunc subgeminas!) in madido tegentibus; semine tereti. — Apparently common on the Californian seaboard: Monterey, Hartweg (1754), Brewer (707); San Francisco, Dr. Kellogg. The specimens

are thinner-leaved than in *C. maculata*, and with the uppermost leaves and the 3 – 5 superior pinnæ of the lower and radical leaves of simple leaflets (or sometimes the lower 2-lobed), giving the plant the aspect of a *Sium*.* The involucels are mostly of broader bracts and the fruit of rather broader outline than in *C. maculata;* the ribs all very corky: carpophore 2-parted: transverse section of the seed orbicular. *C. maculata*, besides the difference in the leaves, and especially in their venation, has the marginal jugæ, as seen in cross section, very much larger than the others, and the seed either flat or decidedly concave on the face.

PIMPINELLA APIODORA: glabra, bi – tripedalis; foliis ternato-decompositis, caulinis petiolo primario spathaceo, foliolis inciso-pinnatifidis trifidisve, segmentis oblongis vel subcuneatis incisis; involucellis e bracteis lineari-subulatis vel setaceis; floribus albis nunc roseo tinctis; fructu late ovato subdidymo, jugis prominulis. — Rocky hills along the coast of California from Mendocino Co., Bolander, to San Francisco, Bolander, Kellogg, &c. Apparently not rare, it is singular that it has remained so long unnoticed. The fleshy root, stems, and seeds are strongly imbued with the odor and flavor of Celery. The fully mature fruit is yet unknown; but the form of the fruit and seed, the numerous vittæ, the absence of calyx-teeth, and the conspicuous pulvinate stylopodia indicate the genus; which is new to this continent, excepting *P. integerrima* (*Zizia integerrima*, DC.), referred to it by Bentham and Hooker.

PODOSCIADIUM, nov. gen. *Scandicinearum.*

Flores polygami, albi. Calycis dentes prominentes, tenues, scariosi vel petaloidei, subulati. Petala obovata, acumine inflexo vel involuto longo, ob costam superne impressam emarginata. Stylopodia brevia, conica. Fructus oblongus, a latere pl. m. compressus, ad commisuram haud constrictus, apice subcontractus, jugis filiformibus vel angustissimis, valleculis latis 1 – 2-vittatis. Semen facie late sulcatum, sulco linea centrali prominula percurso, sectione transversa reniformi. Car-

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* SIUM LINEARE, Michx. I must dissent from the statement in Benth. & Hook. Gen. Pl. p. 888, that in this "valleculis perperam 2 – 3-vittatis dictis"; both this and *S. Carsonii* being found on re-examination to accord with the characters assigned in my Manual, except that the vittæ are very seldom solitary, even in the dorsal intervals. I may add, as farther separating them from *Apium*, that both species have a manifest, but very attenuated, completely 2-parted carpophore.

pophorum bifidum. — Herbæ perennes, glaberrimæ, subsimplices; foliis pinnatim vel subternatim decompositis, segmentis linearibus angustis; umbellis longe pedunculatis pluri-radiatis, terminali fertili, lateralibus masculis, involucris et involucellis e bracteis plurimis subscariosis linearibus seu lanceolatis setaceo-acuminatis. — A nearly allied plant, probably, is No. 6 of Hartweg's Mexican collection, doubtfully appended to *Oreomyrrhis* by Bentham; but it has a simple umbel and obtuse nearly plane petals.

PODOSCIADIUM CALIFORNICUM (*Chærophyllum? Californicum*, Torr. Bot. Whipp. Exped. p. 37): caule 3–4-pedali; segmentis foliorum planis; umbellis 9–12-radiatis; calycis dentibus stylopodiis brevioribus; petalis acumine involuto obtuso; fructus jugis filiformibus obtusis; semine sub vittis in valleculis solitariis magnis pl. m. sulcato. — Knight's Ferry, Stanislaus River, Dr. J. M. Bigelow.

PODOSCIADIUM BOLANDERI: caule 2–3-pedali superne longe nudo; foliis plerisque subradicalibus, segmentis angustissime linearibus fere filiformibus; umbellis multiradiatis; involucelli bracteis angustis tenuiter aristatis pedicellos subæquantibus; calycis dentibus petalis acumine attenuato inflexo subdimido triplove brevioribus; fructus jugis angustissimis elevatis; vittis in valleculis binis obscuris. — Mariposa Trail, Yosemite, Bolander. This cannot well be other than a close congener of the preceding: the only doubt comes from the pair of vittæ in the intervals, which, however, are rather obscurely marked in the thin pericarp, although the seed is well formed. Fruit much smaller than in *P. Californicum*, only a line and a half long; the ribs exceedingly narrow, but sharp and salient. Calyx-teeth ovate-subulate, as thin and delicate as the petals.

MYRRHIS § GLYCOSMA. (*Glycosma*, Nutt.) Fructus juga lævia, haud alæformia. Styli brevissimi. Involucellum nullum. Foliola pauciora, latiora, minus incisa.

M. OCCIDENTALIS (*G. occidentale*, Nutt.): subpuberula; foliolis oblongis sublanceolatisve serratis raro incisis; pedicellis fructiferis flores sterilia subsuperantibus; jugis fructus acutis.

M. BOLANDERI: subpubescens; foliolis ovatis magis incisis; pedicellis fructiferis floribus sterilibus brevioribus; jugis obtusis. — At Lambert's Lake, Mendocino Co., Bolander. Leaflets more numerous than in Nuttall's species, and more like those of *Osmorrhiza*. Pedicels of the fruit only a line and a half long. — Bentham and Hooker have characterized the genus *Myrrhis* upon *M. odorata* alone,

and then added the American species without modifying the general diagnosis.

LIGUSTICUM (CYNAPIUM, Nutt.) APIIFOLIUM. Nuttall's two forms, Hall and Harbour's No. 218 from the Rocky Mountains, and the Californian specimens (some of them with leafless stems) may comprise two or more species; but wholly mature fruit has been collected only by Nuttall. In this the seed is scarcely more concave on the face than in some genuine species of *Ligusticum*, to which genus Bentham and Hooker refer it.

LIGUSTICUM SCOPULORUM: *L.* (*Conioselino*) *Fischeri* affine; mericarpiis parum brevioribus ovali-oblongis; alis angustioribus crassioribus, intermediis et dorsali minus evolutis 1 – 2 sæpe obsoletis; vittis perspicuis majusculis in valleculis omnibus 3 nunc in lateralibus 4; sectione seminum fere reniformi. — Santa Antonita, New Mexico, Dr. J. M. Bigelow, with ripe fruit; the plant enumerated in the Botany of Whipple's Expedition, p. 38, as *Conioselinum Canadense.* Also in the Rocky Mountains of Colorado Territory, being doubtless Parry's No. 156, and Hall and Harbour's 216 (at least in part), published as *C. Fischeri.* Apparently the same collected at Fort Steilacombe, Washington Terr., by Dr. Suckley. Fruit in size and shape intermediate between that of *Conioselinum Fischeri* of the Old World, which Bentham and Hooker refer to *Ligusticum*, and *C. Canadense* which (having the vittæ usually solitary in the dorsal and in pairs in the lateral intervals, and the carpels more orbicular) they remand to *Selinum.* Unless more definite distinctions can be found, it were better to unite *Selinum* with *Ligusticum.* (The *Conioselinum* from Ochotsk, in Rodgers's Expedition, mentioned by Bentham and Hooker, is probably the form or doubtful variety cited in the Flora Rossica and Flora Ochotensis under *C. cenolophioides.*)

LIGUSTICUM MONTANUM = *Thaspium? montanum*, Gray, Pl. Fendl., Pl. Wright, &c., (referred to *Ligusticum* by Bentham and Hooker, but by their characters should be a *Selinum*,) has mericarps in some specimens almost orbicular, including the broad marginal wings, in others oblong-oval; in both the strong vittæ are sometimes single, sometimes double. The foliage is very variable for one and the same species; but the form with long and slender divisions to the leaves shows fruit of both shapes.

ANGELICA LINEARILOBA: glabra; caule valido; petiolis prorsus spathaceo-dilatatis; foliolis longe linearibus acutatis (1 – 2-poll.) inte-

gerrimis nunc 1–3-dentatis seu lobo divaricato instructis in rachin marginatum decurrentibus; involucro involucellisque subnullis; floribus albis; fructus alis disco angusto oblongo paullo angustioribus; vittis semini adhærentibus, lateralibus geminis. — Ostrander's Meadows, Yosemite Valley, alt. 8,000 feet, Bolander. Stem 2 or 3 feet high. The nearly full-grown fruit, including the wing, is oval-oblong, about 4 lines long and 2½ wide; mericarps flat. The stout root not sweet-scented.

ANGELICA BREWERI: glabra vel tenuiter puberula; petiolis spathaceo-dilatatis; foliis triternatis vel triquinatis; foliolis lato-lanceolatis argute dentatis (dentibus cuspidatis) reticulato-venulosis, lateralibus sessilibus basi inæquali hinc sæpe adnata; involucro involucellisque nullis; floribus albis; fructu puberulo oblongo, alis crassis angustis; vittis in valleculis lateralibus quandoque geminis; semine facie concavo (sectione transversa lunata) dorso sub vittis sulcato. — Sierra Nevada, near Ebbett's Pass, and on the Big-tree road, alt. 6,000 feet, Prof. Brewer [and near Donner Lake, Prof. Torrey, with mature fruit]. Stem apparently tall and stout. Fruit 4½ lines long, with wings less than half the width of the disk, cellular, and as thick as the edges of the much-flattened seed: the vittæ large, adherent on the one side to the groove of the seed into which it is received, on the other to the thin pericarp.

FERULA CALIFORNICA = *Leptotænia? Californica*, Nutt. The mature fruit of this, now collected by Bolander [also by Prof. Torrey], but already quite well described by Torrey, in Bot. Whippl. Expl., is traversed with numerous conspicuous, although slender, often anastomosing vittæ, and the winged margin is no thicker than in some species of *Ferula*, to which this plant appears clearly to belong. Its dilated leaflets are in the manner of *Narthex*.

FERULA (LEPTOTÆNIA, Nutt.) DISSECTA, with vittæ obsolete, as in several Old-World species of *Ferula*, has usually, and in some of Nuttall's own specimens, an obvious involucre of many bracts; the fruiting pedicels very short.

FERULA (LEPTOTÆNIA, Nutt.) MULTIFIDA, if, as is likely, the plant in Spalding's Clear Water collection, has no involucre and longer pedicels to the flowers and fruit: the latter I have not seen full grown. There are some indications of one or two more species.

PEUCEDANUM EURYPTERA (*Euryptera lucida*, Nutt.), the good figure of which in the Mexican Boundary Survey, t. 27, is not cited

in Bentham and Hooker's Genera Plantarum, is clearly inseparable from *Tommasinia*, as those authors have indicated, and so to be referred to *Peucedanum*.

GARRYA BUXIFOLIA: foliis parvis ovato-ellipticis mucronatis crassis integerrimis supra mox glabris nitidis subtus argenteo-sericeis; spicis fœmineis pendulis brevibus, bracteis alte connatis plerisque unifloris; ovario glabro. — A low shrub, on the Red Mountains, Mendocino Co., Bolander. Only the female plant. Leaves about the size of those of Box, glossy bright green and glabrous above as soon as they are grown, whitened beneath with a very fine and close silky pubescence which seems scarcely if at all deciduous with age, almost veinless. Female spikes nodding from the first, simple and short, seldom much longer than the leaves. Pedicels very short and included in the truncate-connate bracts; the calyx-teeth obsolete.

GARRYA FREMONTII, Torr. Bot. Whippl. A specimen in fruit found by Mr. Bolander "in a tavern on the Sonora road" in January, 1866, has the leaves oftener obtuse or retuse; the fruiting spikes erect, with bracts like those of the male. Berries glabrous, very short-pedicelled: the two short calyx-teeth manifest.

LONICERA BREWERI (Gray, in Proceed. Am. Acad. 6, p. 537, char. emend.): caule erecto; foliis brevi-petiolatis ovalibus utrinque rotundatis seu majoribus pl. m. acuminatis basique subacutis membranaceis cum ramulis junioribus pubescentibus, pube brevi molli; pedunculis floribus vix duplo longioribus; bracteis bracteolisque consimilibus minimis rotundatis cum basi ovariorum coadunatorum connatis obsolescentibus; corolla lurido-purpurea campanulata late gibbosa ultra medium bilabiata, fauce ad staminum insertionem styloque villosissimis. — Collected at the Mariposa Grove, Bolander, larger and more developed than Prof. Brewer's specimens from Mount Dana. [Also by Prof. Torrey, at Donner's Pass, &c.] The leaves in the present specimens 1½, or the larger and later ones 2 inches in length, and disposed to be acute at both ends or acuminate. Ovaries most commonly united to or near the summit, the short calyx-teeth usually blunt. — The present well-developed specimens show it is not *L. nigra*, nor even *L. Chamissoi*, but the Mandchurian *L. Maximowicii*, Rupr. to which this is most nearly related. In that, however, the pubescence is much more sparse and pilose; the leaves more ovate and taper-pointed, with veinlets conspicuously reticulated; the peduncles much longer; the ovaries longer, tapering, and less united; the style more hairy, &c.

GALIUM PUBENS: perenne, undique pube densa patente cinereum; caulibus (ultrapedalibus) adsurgentibus paniculato-ramosis inermibus; foliis quaternis quinisve ovatis vel oblongis (lin. 4 – 6 longis) fere muticis uninerviis secus margines costamque magis hispidulis; cymulis foliosis paucifloris, pedicellis fructiferis deflexis; corollis albidis vel carneis raro 3 – 5-fidis; fructu ut videtur carnoso, immaturo pubero. — Yosemite Valley and adjacent mountains, Bolander, Torrey. The specimens collected by the former have perhaps only male flowers, on very short pedicels; those collected by the latter have fertile flowers, on pedicels mostly twice the length of the flower and fruit. The pubescence, although soft and velvety to the touch, is hispidulous, but not uncinate, although rather hispid on the margins of the leaves; the angles of the stem not at all armed or roughened.

GALIUM BOLANDERI: glabrum; caulibus e radice perenni ramossimo diffuso (ultrapedali) ramulisque fere lævibus; foliis quaternis lato-linearibus uninerviis margine rariter scabro-hispidulis (3 – 5 lin. longis); paniculis laxe floribundis; pedicellis flore purpureo brevioribus vel æquilongis; fructu (immaturo) subgranulato glabro. — Sierra Nevada, on the Mono Trail, Bolander. — Flowers small: the corolla only a line or a line and a half in diameter, apparently deep dull purple.

GALIUM ACUTISSIMUM: scabrido-puberulum, inerme; caule gracili ramoso; foliis quaternis (lin. 3 longis) ovato-lanceolatis seu lanceolatis valide uninerviis sensim in cuspidem rigidum acuminatis; cymulis paucifloris; floribus albis brevissime pedicellatis; ovario glabro. — Between the Rio del Norte and New Mexico, Dr. Newberry. A very small-flowered species, remarkable for its gradually attenuated, cuspidate, rather rigid leaves.

BRICKELLIA INCANA: tomento implexo (ætate subdeciduo) dealbata; foliis ramorum alternis subcordatis vel ovatis sessilibus fere integerrimis basi subtrinervatis; capitulis ramos terminatibus breviter pedunculatis multifloris; involucri pluriserialis squamis obtusis, extimis ovatis, intimis linearibus; acheniis sericeis. — Providence Mountain, in the Mohave district, 1861, Dr. J. G. Cooper. Only a single specimen, which wants the lower part of the stem. Leaves rather thin, the largest present less than an inch long, those on the flowering branchlets barely half an inch long. Heads single on the branchlets, even larger than those of *B. lanata* (an inch long, very many-flowered), the down finer and whiter, completely hiding the veins.

LESSINGIA LEPTOCLADA: floccoso-lanata, demum glabrescens, haud viscosa; caule erecto virgato superne ramos floridos sæpius corymbosos filiformes proferentibus; foliis infimis spathulatis subdentatis, superioribus lanceolatis linearibusque integerrimis basi brevissime sagittato-adnatis, ramorum parvis nunc raris in bracteas subulatas transeuntibus; capitulis 5 – 20-floris solitariis bi – quinisve ramulos seu pedunculos terminantibus; involucri squamis lanceolato-linearibus acutatis mucronatis; corollis consimilibus purpureis, limbo æqualiter 5-partito; pappo corollæ tubum adæquante; radice (ut in omnibus sp.) annua. — Tres formæ admodum diversæ, ut videtur colligendæ: — TYPICA, 1 – 2-pedalis, capitulis 18 – 20-floris; involucro turbinato pluriseriali, squamis exterioribus gradatim brevioribus; ramis floridis gracillimis nunc simplicibus apice 1 – 3-cephalis, nunc proliferis pedunculis filiformibus corymbosis. — Yosemite Valley, in sandy soil, Bolander. [And now received from the collections of Bridges and Torrey, and in a collection from Dr. Kellogg, said to be from near San Francisco.]

Var. MICROCEPHALA: sesqui – bipedalis; caule foliisque caulinis (argute dentatis rigidioribus) denudatis leviter glanduloso-scabridis; ramis floridis filiformibus effuse paniculatis decompositis; capitulis parcis lin. 3 tantum longis involucro 5-floro; turbinato. — On Bear Mountain, Dr. Torrey, 1865. I take this to be a form of *L. leptoclada*, probably from a more exposed station, and with depauperated inflorescence.

Var. TENUIS: 3 – 7-pollicaris; capitulis paucis 5 – 7-floris; involucro angusto e squamis paucioribus attenuatis minus imbricatis. — Yosemite Valley, with the typical form, of which, as Mr. Bolander did not distinguish the two, I infer it to be a remarkable depauperate state. But Dr. Torrey, who likewise collected it, regarded the three plants as wholly distinct species. Further observation will determine. The corolla in all is apparently light purple or whitish, as in all the other species except *L. Germanorum*, where they are yellow: the lobes 2 or 3 lines long, oblong, becoming linear, their margins induplicate in æstivation up to the nerves (as in the others): inner flowers at length probably as large as the outermost: genitalia included: appendages of the style tipped with a prominent cusp much exceeding the bristles.

CORETHROGYNE SPATHULATA: caulibus cæspitosis decumbentibus apice vel ramis paucis adscendentibus foliosis monocephalis; foliis obovato-spathulatis versus apicem serratis, superioribus ovalibus oblongisve, summis in bracteas lineares transeuntibus; capitulo pro genere maximo; involucro hemisphærico; squamis linearibus vel subspathulatis

acutis glandulosis subæquilongis disco æqualibus; paleis inter flores nullis. — On the coast at Shelter Cove and at Fort Bragg, Humboldt Co., Bolander. "Forming large patches or tufts; the stems lying on the ground, only the heads rising above the grass." Ascending stems or branches a foot or less high, covered like the foliage with the floccose cottony down of the genus. Leaves $\frac{3}{4}$ – 2 inches long. 6 – 10 lines wide, thin. Heads $1\frac{1}{2}$ inches or more in diameter, including the numerous violet-purple rays. The narrowest-leaved specimens might pass for the broadest-leaved form of the variable *C. filaginifolia*, but the heads are like those of *C. Californica*, only still larger. From the habit, the white-cottony leaves, and the showy heads of flowers, this would be a very desirable acquisition to the gardens.

Aster Chilensis, Nees, common about San Francisco, was doubtless collected in California by Hænke, and not in Chili, where, apparently, it does not occur. So that Nuttall's name, *A. Durandi*, distributed with specimens, but not published, had better be substituted.

Aster (Orthomeris, Torr. & Gr., *Xylorhiza*, Nutt.) Andersonii (*Erigeron, Celmisia, Andersonii*, supra, 6, p. 540): lana tenui mox decidua glabratus; caulibus e rhizomate nudo adsurgente erectis simplicissimis monocephalis; foliis gramineis linearibus coriaceis sæpe nitidis 3 – 5-nerviis (angustioribus fere uninerviis), radicalibus spithamæis, caulinis brevibus in bracteas subulatas sensim decrescentibus; capitulo nudo hemisphærico ($\frac{1}{2}$ – $\frac{3}{4}$ poll. lato); involucri subtomentosi squamis lineari-lanceolatis acutis subherbaceis laxis 2 – 3-seriatis subæquilongis; ligulis oblongis (cæruleis vel purpureis); styli ramis fl. herm. longe tenuiter subulatis, parte hispida terminali quam stigmatosa 3 – 4-plo longiori: acheniis oblongis villosis 4 – 6-costatis; pappi setis subæqualibus barbellulatis. — Nevada, Carson City, Dr. C. L. Anderson. California, Lake Tenaya in the Sierra Nevada, alt. 8,000 feet, Prof. Brewer. Westfall's Meadows in the Yosemite, 8,000 feet, and in meadows on the Tuolumne, 9,700 feet, smaller and smoother specimens, H. N. Bolander. The form from the highest station has the radical leaves only 2 to 4 inches long and barely a line wide; the others of Bolander have the slender flowering stems 6 to 9 inches high, and the conspicuously nerved Xyris-like radical leaves 2 lines wide. Not satisfied with my former reference of this plant to *Erigeron*, I now perceive that its pappus is neither scanty nor uniserial, and that it must rank with Nuttall's *Xylorhiza*, *Aster Xylorhiza*, Torr. & Gray Fl.

ASTER TORTIFOLIUS (non Michx.) = *Aplopappus tortifolius*, Gray, afterwards *Townsendia* (*Megalastrum*) *tortifolia*, Gray, and the related A. WRIGHTII, which had also been referred to *Townsendia*, are both Asters of this *Xylorhiza* section.

ERIGERON SUPPLEX: humile, subvilloso-pubescens; caulibus e basi decumbente adsurgentibus simplicissimis apice nudo monocephalis; foliis crebris integerrimis spathulato-lanceolatis summisve linearibus sæpe glabratis hirsuto-ciliatis; involucri squamis linearibus acuminatis dorso villosis discum adæquantibus laxis; ligulis nullis; corollis fl. disci marginalium rariter difformibus 2–4-dentatis; acheniis hispidulis binervatis; pappo e setis barbellato-scabris corolla paullo brevioribus setulisque nonnullis brevibus. — Roadside near Mendocino City, Bolander. I have also a specimen collected by Dr. Andrews, the station not recorded. Stems 3 to 6 inches long, apparently numerous, and spreading from a perennial root. Lower and larger leaves little over an inch in length and 3 lines in width, tapering into a petiole-like base. Head about half an inch in diameter, very many-flowered; the yellow disk flowers commonly all alike and perfect; sometimes a few of the outermost a little enlarged, and, as it were, essaying to become ligulate. Tips of the style very obtuse.

APLOPAPPUS (STENOTUS) ACAULIS = *Stenotus acaulis*, Nutt., a Rocky-Mountain species, was collected on Mount Davison, Nevada, by Mr. H. G. Bloomer.

APLOPAPPUS (PYRROCOMA) WHITNEYI: late cæspitosus, glanduloso-scabridus; caulibus (ultrapedalibus) tenuiter pubescentibus usque ad apicem æqualiter foliosis; foliis oblongis subamplexicaulibus venulosis grosse argutissime dentatis, imisve angustioribus integrioribus; capitulis paucis subpaniculatis; involucro 20–25-floro oblongo-campanulato, squamis lanceolatis acutis appressis; ligulis 6–8 angustis discum paullo superantibus. — Mono Trail and Sonora Pass, in open woods, alt. 9,000 feet; grows in large tufts, Bolander. This well-marked new species (named for the Director of the Survey) has the foliage of a *Grindelia* or of *Aplopappus Nuttallii*, and few or several rather small heads. The leaves are scarcely coriaceous, an inch or an inch and a half long, acute or obtuse, all but the lower beset with sharp teeth even to the clasping or half-clasping base. Peduncles seldom longer than the heads or the subtending leaf, terminated by one to three more or less foliolose bracteate heads; these three fourths of an inch long in fruit. Scales of the involucre few-ranked. Branches of the style,

fulvous rigid pappus, and glabrous striate-ribbed linear achenia as in the species of this section.

APLOPAPPUS (PYRROCOMA) APARGIOIDES: cæspitosus, humilis, villosulus seu glaber; caulibus floridis subscapiformibus e caudice crasso folia pleraque radicalia rosulato-conferta linearia seu lanceolata laciniato-pinnatifida superantibus mono-tricephalis; involucro hemisphærico multifloro, squamis 3-4-seriatim imbricatis sæpius obtusis appressis; ligulis 20-24 oblongis exsertis. — At Soda Springs, on the Tuolumne River, alt. 9,700 feet, Bolander. Also, sparingly, Carson City, Nevada, Dr. C. L. Anderson. Stems about a span high, slender, naked above; the leaves reduced to small linear bracts, simple or divided into one or two peduncle-like branches. Radical leaves 2-5 inches long, in shape not unlike those of *Leontodon autumnale*, but rigid. Head nearly half an inch in diameter, naked. Style, glabrous striate achenia, and pappus of the section; the later not very copious nor rigid. One form has the stem slightly villous-pubescent and the margins of the radical leaves sparingly hirsute-ciliate: the other form is glabrous.

APLOPAPPUS (PYRROCOMA) PANICULATUS = *Homopappus paniculatus*, Nutt., var. VIRGATUS: capitulis numerosis minoribus. — Bridgeport, on the eastern side of the Sierra, in alkaline soil, Bolander. Dr. Anderson collected it at Carson City, Nevada, equally with slightly hairy ovaries; but the heads larger, nearly as in Nuttall's plant.

APLOPAPPUS (ERICAMERIA) BLOOMERI (Gray, supra, 6, p. 541), var. ANGUSTATUS: foliis angustissime linearibus; capitulis racemosis plerumque 10-12-floris, ligulis 1-4 quandoque nullis. — On Mount Shasta, alt. 6,000 feet, Prof. Brewer (1415); Little Yosemite Valley, Empire Camp on the Yosemite Trail, and Soda Springs, alt. 9,700 feet, Bolander. From an imperfect specimen it is probable that this was also collected on the head-waters of the Sacramento in Wilkes's Exploring Expedition. It seems to be connected by gradations with the ordinary form of *A. Bloomeri*. It is a shrub, one or two feet in height, according to Mr. Bolander.

LINOSYRIS (CHRYSOTHAMNUS) BOLANDERI: fruticosa, pedalis, subviscosa; ramis lana valde implexa dealbatis; foliis spathulato-linearibus seu oblanceolatis acutatis haud rigidis subtrinerviis; capitulis paucis pluribusve ad apicem ramorum corymboso-congestis bracteis 1-2 linearibus iisdem dimidio brevioribus stipatis; involucro cylindraceo 7-11-floro, squamis 10-12 pauciseriatis lanceolato-linearibus attenu-

ato-acuminatis fere glabris; receptaculi alveolis in dentes subulatos productis; acheniis sericeo-pubescentibus. — Mono Pass, at 9 – 10,000 feet of elevation, Bolander. — In aspect and foliage (except that the leaves are more lanceolate and acute or acuminate), this much resembles *Aplopappus Macronema*, Gray (*Macronema discoidea*, Nutt.) which is one of the many links connecting *Aplopappus* and *Linosyris;* but it is a near relative of *L. Parryi*, and a genuine *Chrysothamnus*. The narrow and much crowded heads are about three fourths of an inch in length.

CONYZA COULTERI (*C. subdecurrens*, Gray, Pl. Fendl. p. 78, & Pl. Wright. 1, p. 102, non DC.): molliter viscoso-pubescens; caule ramisque strictis ad apicem usque foliosis; foliis adnato-sessilibus lineari-oblongis vel inferioribus spathulatis plerisque pinnatifido-dentatis incisisve; panicula conferta virgata; capitulis parvis (sesquilineam longis); involucro disco breviore, squamis hirto-viscosis linearibus acutis. — This is Coulter's No. 285 and 286, and has recently been collected near Fort Mohave by Dr. Cooper. It is quite different from the Mexican *Conyza* or *Erigeron subdecurrens*, which I now possess from Dr. Schultz. The pistillate flowers have no ligule, and the hermaphrodite flowers are only 5 – 7; so that, although the pappus is not copious, the plant is better placed in *Conyza*.

FRANSERIA ERIOCENTRA: fruticosa; foliis oblanceolatis vel spathulatis sæpius sinuato vel inciso-dentatis cinereis, junioribus ramulisque villosulis; involucris fructiferis fusiformibus unilocularibus monospermis cum aculeis longis validis longe lanatis. — East slope of Providence Mountain, Arizona, May, 1861, Dr. J. G. Cooper. In fruit only; the male flowers not seen. Apparently a low shrub. Spines of the involucre 2 lines long, larger than the diameter of the cell, thickly clothed with long white wool.

ANCISTROCARPHUS, Nov. Gen.

Capitulum pluriflorum, heterogamum; floribus omnibus tubulosis, singulis palea receptaculi suffultis; exterioribus 5 – 10 fœmineis in receptaculo breviter cylindrico 1 – 2-seriatis, corolla filiformi; centralibus 5 masculis, corolla 4-dentata. Involucrum præter paleas flores involventes nullum. Paleæ subcoriaceæ, ovatæ, acuminatæ, fl. fœm. saccatæ, apiceque breviter scarioso-appendiculatæ modo *Psilocarphi*, achenium obovato-fusiforme vix obcompressum includentes cum eo tardius deciduæ; steril. 5 majores flores longius superantes, concavæ vel sub-

cymbæformes, in cuspidem apice uncinatam rigidam sensim acuminatæ, persistentes, fructu delapso stellato-patentes. Pappus nullus. — Herba exigua, digitalis, annua, *Filaginis Gallicæ* facie; foliis linearibus alternis, summis capitulum vel glomerulum 3–4-cephalum sessile involucrantibus.

Ancistrocarphus filagineus. — Dry hillsides, Round Valley, Eel River, Mendocino Co., May, Bolander. Stems simple or sparingly branched, slender, 2 to 4 inches high. Leaves narrowly spatulate-linear, clothed as is the whole plant with light flocculent wool. Paleæ of the fertile flowers arachnoid-woolly, especially towards the involute margins, those of the sterile flowers fully twice larger, becoming nearly two lines long, more naked, the hooked tips prominent, making the head or glomerule squarrose. To provide for this little plant I am obliged to add yet another to the Micropoid genera. This is related on the one hand to Nuttall's *Psilocarphus*, of which it has the achenia and the enclosing fructiferous paleæ; on the other to *Hesperevax caulescens* (which may be completely separated from *Evax*, to which I referred it in Bot. Whipp. p. 45, t. 10), having like that a whorl of coriaceous paleæ surrounding the sterile flowers. One would like to combine these last; but the habit does not invite it, and the naked fertile paleæ of *Hesperevax* are open as in *Evax*, although apparently persistent.

Balsamorhiza Bolanderi: glutinosa, fere glabra; caulibus (subpedalibus) e caudice longo adsurgentibus superne 3–5-foliatis monocephalis; foliis omnibus petiolatis ovatis subrotundisve sæpissime leviter cordatis acuminulatis integerrimis; capitulo maximo; involucro duplici, exteriori foliaceo 6–8-phyllo, phyllis ovatis oblongisve acutis disco longioribus, interiori e squamis uniseriatis lanceolatis supra medium villosissimis paleis receptaculi similibus; acheniis (compressis vel obcompressis) obovato-oblongis glabris areola epigyna parva. — Shady hillsides, at Auburn, April, 1865, Bolander. "Rootstocks large; whole plant glutinous and of a strong resinous smell." The aspect of this remarkable species is that of a *Wyethia*. Radical and cauline leaves alike (2 to 4 inches long, on petioles of 6 to 20 lines in length), but the base of the stout stems bears one or two scales in place of foliage; the uppermost leaf near the head or an inch or two below. Head in the dried specimens 2 inches in diameter; the yellow rays 12 or more, an inch and a half long, broad. Achenia remarkably flattened for the genus. [This, as now appears, was collected in 1844 by Fremont on the upper Sacramento, and later by Major Rich.]

WYETHIA OVATA: tomentoso-pubescens; caule valido tripedali superne ramoso, ramis monocephalis; foliis ovatis acutissimis triplinerviis subtus canescentibus, majoribus nunc subcordatis deltoideisve omnibus petiolatis; capitulis mediocris; involucri squamis lanceolatis, exterioribus laxis discum haud superantibus; ligulis 10 - 14; pappo calyci formiirregulari exaristato. — Dry hillsides at Clark's, Mariposa Co., Bolander. [Also collected by the late Thomas Bridges.] — Cauline leaves 5 - 7 inches long, on petioles of 1 or 2 inches; those of the flowering branches 2 or 3 inches long and less truncate or rounded at base; the principal veins and ribs prominent underneath; veinlets not reticulated. Heads an inch in diameter. Rays often with imperfect stamens. Achenia about 4 lines, the pappus nearly a line long.

RUDBECKIA CALIFORNICA: caule simplici inferne glabro apice longe nudo pedunculiformi monocephalo; foliis pube brevi molli indutis ovato-lanceolatis penninerviis membranaceis parce inæqualiter serratis nunc inciso-dentatis, caulinis nunc lyrato-tripartitis, summis semi-amplexicaulibus; involucri squamis linearibus subuniseriatis; ligulis cuneato-oblongis sesquipollicaribus discum cylindraceum adæquantibus vel superantibus; fl. disci paleis acheniisque *R. occidentalis*, Nutt. — Mariposa Big-tree Grove, Bolander. [Also in a collection of the late Thomas Bridges.] Stem 3 feet high, somewhat pubescent at the summit. Leaves 3 to 6 inches long, all but the upper contracted into margined petioles, occasionally obscurely triplinerved. This may prove to be a radiate variety of *R. occidentalis*, in which traces of pubescence are sometimes to be found.

RIGIOPAPPUS LEPTOCLADUS, Gray, described from Dr. Lyall's collection (supra, 6, p. 548), was gathered by Mr. Bolander at Newcastle in California, in 1865, and on Russian River in 1866.

BURRIELIA LANOSA, Gray, in Bot. Whipp. (Pacif. R. R. 4), p. 51, & Bot. Mex. Bound. p. 96. Near Fort Mohave, Dr. J. G. Cooper. Better developed specimens than before collected, 2 to 4 inches high, diffusely branching; the leaves mostly narrowly spatulate, and the cylindraceous heads peduncled. The rays prove to be *white*, and the paleæ of the pappus vary from 8 to 12. All the upper leaves are alternate. The involucre is that of a *Bahia* of the section *Eriophyllum:* but the setiform appendages or cusps to the anthers (here remarkably long) are as in *Burrielia*. They are similar, however, in *Bahia rubella* and *B. Wallacei*, Gray, to which, especially to the former, the present plant is very nearly related.

BURRIELIA (DICHÆTA) MARITIMA: arenoso-pubescens, mox glabrata; caulibus diffusis; foliis oblongo-linearibus integerrimis trinervulis; pedunculis folia paullo superantibus; involucri squamis ovali-oblongis 6–8; ligulis totidem brevissimis; corollis fl. disci (circiter 20) fauce campanulata; acheniis oblongo-linearibus pubescentibus; pappi aristis 3–5 scabris achenio paullo brevioribus setulisque plurimis interjectis. — On the Farallones, rocky islets off San Francisco, Mr. F. Gruber. A span high: leaves an inch long: head 4 lines long: the broad ligules barely equalling the disk.

LEPTOSYNNE NEWBERRYI: *L. Douglasii* facie, stylis, etc.; tubo corollarum brevioribus annulo barbato inconspicuo; acheniis ala lata tenui lævi cinctis (corona obsoleta) fere epapposis. — Sitgreaves Pass, Arizona or New Mexico, Dr. Newberry. Camp Grant, Arizona, Dr. Edward Palmer. There are no capitate hairs or glands on the broad and thin wing of the achenium, but some very short ones on the dorsal face of its body. The flowers are intermediate between *L. Douglasii* and *L. Stillmanii.*

LEPTOSYNNE MARITIMA = *Tuckermannia maritima,* Nutt. The characters upon which Nuttall's genus rested, never strong, are now quite invalidated.

RIDDELLIA COOPERI: ramosissima (bipedalis, basi frutescens?), lana appressa canescens; foliis augusto-linearibus integerrimis (imis ignotis); pedunculis ramos terminantibus solitariis monocephalis gracilibus; ligulis sæpius 4; pappi paleis oblongis aut integris aut eroso-laceris corolla disci et achenio glabro 2–3-plo brevioribus. — Gravelly banks at Fort Mohave, Dec. 1861, Dr. J. G. Cooper. On the Colorado, Dr. Newberry. Camp Grant, &c., Arizona, Drs. Elliott Coues and Edward Palmer. In Dr. Cooper's and Dr. Newberry's specimens only are the paleæ of the pappus somewhat laciniate, making an approach to *R. arachnoidea,* the *Psilostrophe* of De Candolle's *incertæ sedis,* — a name which, although a year or two earlier in publication, we trust may remain disused, having been accompanied by an insufficient, and, in some important respects, erroneous character.

HELENIUM BOLANDERI: tomentuloso-pubens, mox glabrescens; caule valido (pedali ad sesquipedalem) apice aphyllo monocephalo rariusve ramoso 2–3-cephalo; foliis ovatis obovatis vel spathulato-lanceolatis integerrimis ima basi 5–7-nervatis in caulem pl. m. decurrentibus, imis in petiolum angustatis; capitulo pro genere maximo; ligulis plurimis aureis disco subgloboso æquilongis involucro multo longioribus;

receptaculo hemisphærico; pappi paleis 6–8 e lanceolata vel subulata sensim aristatis inferne rariter spinuloso-dentatis laciniatisve corollam subæquantibus achenio immaturo villoso subduplo longioribus. — Plains of Mendocino, Sept. 1865, and (1866) from Shelter Cove on the borders of Humboldt Co. down to the Albion River. Very common in moist open meadows and sphagnous swamps. The head with the copious rays expanded is full three inches in diameter in the more luxuriant specimens. — This, much the most showy species of the genus, may well bear the name of the indefatigable discoverer.*

ACTINELLA COOPERI: bipedalis, laxe ramosa, puberula; foliis (superioribus) tripartitis segmentis anguste linearibus; capitulis subpaniculatis breviter pedunculatis iis *A. Richardsonii* similibus etsi duplo triplove majoribus; pappi paleis 5 late ovatis muticis corolla viscoso-pubente plus dimidio achenio paullo brevioribus. — On Providence Mountain in the Mohave district, alt. 5,000 feet, May, June, Dr. J. G. Cooper. Lower part of the plant not collected. Rays half an inch long, 3-lobed at the apex.

HULSEA BREVIFOLIA: viscoso-pubescens; caulibus e radice gracili adscendentibus sæpius ramosis (1–1½-pedalibus) ad apicem usque æqualiter foliosis; foliis oblongis lingulatisve ultra medium repando-dentatis sessilibus, infimis basi attenuata spathulatis; capitulis ramos terminantibus minoribus; involucri squamis linearibus obtusiusculis biseriatis; ligulis 10–12 luteis; pappi paleis 2 dimidium tubi nudiusculi corollæ adæquantibus, 2 alternis paullo brevioribus. — Mariposa Big-tree Grove, Bolander. Root perhaps only annual or biennial. Stem and branches slender. Leaves thin, 1–1½, or some of the lower ones 2 inches long. Heads short-peduncled. Involucre half an inch long, nearly equalling the disk, of about 20 scales. Rays small. Branches of the style in the perfect flowers tipped with a very short blunt cone. Achenia 3½ lines long, the villous hairs one half shorter than the conspicuous pappus. Mr. Bolander also collected, on Mount Dana, specimens of the striking *H. algida* a foot in height, and in the Yosemite Valley a single specimen of the following.

HULSEA HETEROCHROMA: viscoso-pubescens; caule e radice gracili erecto bipedali ad apicem usque æqualiter foliosis oligocephalis;

* HELENIUM (HECUBÆA DC.) SCORZONERÆFOLIA, var. GHIESBRECHTII: acheniis pappo minimo multipaleolato coronatis, paleolis latis truncato-obtusissimis insiso-denticulatis. — Chiapas *Ghiesbrecht.* Except as to the pappus this seems to be exactly De Candolle's *Hecubæa.*

foliis argute dentatis oblongis vel summis ovatis imis basi breviter attenuata subspathulatis; involucri squamis 2–3-seriatis lanceolatis; ligulis circiter 30 parvis rubellis; pappi paleis oblongis, 2 tubi villosissimi corollæ dimidium adæquantibus, 2 alternis brevioribus. — Yosemite Valley; only one specimen seen, Bolander. — Related to the preceding; but the heads (four or five and racemose at the summit of the stem) large; rays much more numerous and smaller, the slender ligule only 3 lines long and reddish purple, tube of the corolla conspicuously villous, and leaves with sharp salient teeth, the larger almost 3 inches long.

LAYIA PENTACHÆTA, Gray in Bot. Whipp. p. 108, t. 16. Specimens collected by Mr. Bolander in 1865, at Forest Hill, mixed with *L. gaillardioides* (distinguishable only by the pappus), have in some cases the pappus reduced to two or three setæ or no pappus at all. It is then still readily distinguishable from the following by the copious stipitate glands, uniformly and deeper colored rays, naked receptacle, and scales of the involucre loosely hirsute, without the short strigose bristles of

LAYIA (OXYURA) CHRYSANTHEMOIDES. *Oxyura chrysanthemoides* and *Hartmannia ciliata*, DC. This is seldom collected; but it occurs in Mr. Bolander's and Dr. Kellogg's recent collections.

CALYCADENIA MOLLIS; virgata, pube brevi molli (nusquam hispida vix villosa) cinerea; glomerulis axillaribus dissitis breviter pedunculatis; ligulis 2–3 tubo brevi, lobis rotundatis æqualibus; floribus disci 4–6; paleis receptaculi truncato-obtusis subapiculatis eglandulosis; pappi paleis circiter 5 subulato-aristiformibus scabris corolla paullo brevioribus nunc 1–2 additis brevibus oblongis muticis. — At Clark's, Mariposa Co., Bolander. — About a foot and a half high. Principal cauline leaves 1 or 2 inches long, those of the axillary fascicles and the floral ones or bracts more or less glanduliferous. Fertile achenia rugose; sterile ones a little hairy on the angles.

ANISOCARPUS BOLANDERI: caule elato (3–4-pedali); foliis plerumque integerrimis, inferioribus linearibus elongatis (6–10-pollicaribus lin. 4–6-latis), superioribus brevibus (1–3-pollicaribus) e basi lata lanceolatis; capitulis majoribus; ligulis 15–20; fl. disci paleis pappi 5–6 angustissime subulato-linearibus plumoso-fimbriatis corollam subæquantibus. — Mariposa Big-tree Grove, Bolander. Heads twice the size of those of *A. madioides*, and with about twice as many flowers, the plant similarly hirsute and viscous. Ovaries of the disk-

flowers linear, ovuliferous, but manifestly sterile. Mature fruit not seen. Paleæ of the receptacle between the ray and disk-flowers linear, unconnected. An interesting congener of the original *Anisocarpus* of Nuttall, — a genus which, thus supplemented, may fairly be kept distinct from *Madaria.*

MADARIA ELEGANS, DC., var. DEPAUPERATA: spithamæa, gracillima; foliis ut in var. *corymbosa* eglandulosis; ligulis 2 – 4; fl. disci circ. 12. — Open woods on Mono Trail, 9,000 feet, Bolander. All the known forms of *Madaria* are manifestly of one species; the present is remarkable for its diminutive size and a corresponding reduction in the number as well as the size of the flowers.

ARTEMISIA PARRYI: *Abrotanum*, glaberrima; caule simplici (spithamæo ad subpedalem) e radice perenni folioso; foliis 2 – 3-pinnatipartitis, pinnis 5 – 9 confertis, segmentis linearibus acutis; panicula racemosa polycephalo; capitulis nutantibus; involucri squamis ovatis obtusisimis margine scarioso atro-fusco; floribus marginalibus fœmineis paucis, cæteris fertilibus; corollis glaberrimis. — Huefano Mountains, New Mexico, Dr. C. C. Parry, Sept. 1867. Heads nearly 3 lines in diameter: segments of the leaves crowded, 3 to 5 lines long.

CACALIA NARDOSMIA: laxe flocсoso-lanata; caule pedali 1 – 2-foliato apice subracemoso-5 – 7-cephalo; foliis plerisque radicalibus reniformi-rotundatis 5 – 9-fidis, lobis grosse inciso- vel sinuato-dentatis nunc sublobatis; capitulis circa 50-floris; involucri ecalyculati squamis 16 – 20 lanceolatis acuminatis disco parum brevioribus; floribus cerinis; styli ramis obtusiusculis nudis; pappo albo rigidiusculo. — In open pine woods, near the Geysers in Sonoma Co., on high ridges along Eel River, Mendocino Co., and in similar situations in Humboldt Co., April and May, Bolander. The foliage of this interesting plant strikingly resembles that of *Nardosmia palmata.* Heads almost an inch in diameter, short-peduncled, showy: the "flowers of the color of yellow beeswax, rather vivid, and with the odor of honey or beeswax." Notwithstanding the yellow hue, I refer the plant to *Cacalia.* The flowers are all alike and perfect: the style is of the Senecionoid sort; its branches narrowly linear, flat on the inner, slightly convex on the outer face, which is minutely and uniformly upwardly scabrous throughout; the inner face bearing strong stigmatic lines which vanish gradually as they run together nearly at the apex, where, however, there is no short cone, nor ring of minute hairs, nor indeed any vestige of appendage. A few plants with a somewhat similar style

have been referred to *Senecio*, to which I am unwilling this should be added, notwithstanding the yellow hue of the flowers.

SENECIO CLARKIANUS: elatus, glaber; radice perenni; caule stricto (3 – 4-pedali) simplici folioso apice corymboso-5 – 20-cephalo; foliis lanceolatis utrinque attenuatis laciniato-pinnatifidis dentatisve, dentibus patentissimis argutis; involucro bracteolis plurimis filiformi-subulatis laxe calyculato, squamis linearibus acuminatis; ligulis 10 – 15; acheniis glabris. — In Clark's meadow, below the Mariposa Big-tree Grove, Bolander. This striking tall species may well bear the name of the valued guide and mountaineer, Galen Clark, in whose meadow it grows, and who has done so much to make the Mariposa Grove of *Sequoia gigantea* accessible. Lower leaves tapering into a slender petiole, with the blade 6 – 12 inches long. Heads rather large, 6 to 8 lines long; the yellow ligules about half an inch in length.

SENECIO MENDOCINENSIS: lana flocculosa decidua glabrescens; radice perenni; caule valido sesquipedali apice nudiusculo corymbuum 5 – 8-cephalum compactum gerente; foliis succulentis denticulatis, radicalibus et inferioribus ovalibus oblongisve obtusis in petiolum angustatis, sequentibus lanceolatis sessilibus, supremis in bracteas subulatas diminutis; involucro pluribracteolato, bracteolis setaceo-subulatis laxis squamas proprias lanceolatas scarioso-marginatas acuminatas subæquantibus; ligulis 12 – 15 oblongis brevibus; ovariis glabris. — Open plains at Noyo, Mendocino Co., May, Bolander. "Leaves thick and succulent," according to Mr. Bolander; the lower 3 or 4 inches long besides the petiole. The specimens resemble some forms of *S. lugens* (including *S. exaltatus*, Nutt.); but the heads are considerably larger, with more pointed scales of the involucre, and calyculate with numerous very slender and conspicuous bractlets.

SENECIO BOLANDERI: tomento tenui deciduo glabratus; caule e radice perenni assurgente subpedali folioso; foliis omnibus pinnatisectis petiolatis, foliolis 5 – 7 rotundatis vel subcuneatis inciso-3 – 5-lobatis (lin. 4 – 8 longis) cum 2 – 6 inferioribus parvis sparsis sæpius integerrimis, imis quandoque stipuliformibus; capitulis paucis subcorymbosis; involucro e calyculato, squamis 12 – 15 linearibus; ligulis 4 – 6; ovariis glabris. — Sandstone Bluffs at the mouth of the river below Mendocino City, May, Bolander. The foliage of this well-marked species may be likened to that of a *Poterium* or of some *Potentilla*: the leaflets are seldom at all confluent. Involucre about 4 lines long; the yellow ligules 4 or 5 lines long.

ARNICA PARVIFLORA: breviter pubescens, multicaulis; foliis inæqualiter dentatis, inferioribus subcordatis longe petiolatis, superioribus parvis sæpe alternis sublanceolatis spathulatisve in petiolum marginatum angustatis, sensim in bracteis transeuntibus; capitulis plurimis paniculatis pro genere parvis; ligulis nullis; acheniis minutim glandulosis glabris. — Humboldt Co., in the northern part of California, in thickets, Bolander. Rootstocks slender and branching. Stems a foot high, slender. Radical and lower leaves 1 to 2 inches long, on petioles of 1½ to 3 inches in length. Heads 6 or 7 lines long, on rather slender peduncles. Involucre slightly pubescent, of about 12 scales; the flowers 20 to 30. Rays wanting in all the specimens. Achenia only 2 lines long.

PSATHYROTES ANNUA: Gray, Pl. Wright. 2, p. 100, non Pl. Thurb. p. 323, &c. Mono Lake, Bolander. [Also on sterile saline plains, Humboldt, Humboldt Co., Nevada, Dr. Torrey.] — Here, at length, we have good and abundant specimens of Nuttall's plant, the *Bulbostylis* (*Psathyrotus*) *annua* of Pl. Gambel.; with which, in the lack of sufficient materials, I had confounded a related but distinct species. The character of the genus moreover needing some correction, a revision is offered in the appended note.*

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* PSATHYROTES, Gray, Pl. Wright. 2, p. 100.

Capitulum homogamum, multiflorum. Involucrum circ. biseriale; squamis disco subæqualibus. Receptaculum convexum vel planum, nudum. Corollæ e tubo proprio brevissimo cylindricæ, apice 5-dentatæ, dentibus brevibus latis extus villosis. Stamina prope basim corollæ inserta: antheræ elongatæ, e caudatæ, inclusæ, demum semi-exsertæ. Styli rami compressi, capitellato-truncati vel obtusi. Achenia turbinata vel oblonga, villosa. Pappus pilosus, corolla brevior, setis rigidulis inæqualibus (vix seu levissime serrelalis). Herbæ parvulæ, depressæ, monocarpicæ, subviscosæ, odore balsamico graveolentes; foliis alternis dilatatis petiolatis; floribus luteis.

§ 1. Ramosissimæ, foliosæ; foliis *Atriplicis* facie longe petiolatis; capitulis alaribus et subcorymbosis breviter pedunculatis post anthesin nutantibus. Involucri squamæ 5 exteriores persistentes; cæteræ tenuiores, subscariosæ, trinerves, cum floribus 16-20 deciduæ. Corollæ angustæ, apice lana longa implexa arachnoideæ. Styli rami breviusculi, apice subcapitellato-truncati. Achenia villosissima, pilis rigidiusculis summo apice plerisque (ut a Torreyo dicitur) bifidis.

P. RAMOSISSIMA: albo-tomentosa; foliis rotundatis parce crenatis; involucri squamis oblongis obtusis, 5 exterioribus latioribus obtusissimis; floribus saturate flavis; acheniis breviter turbinatis; pappi setis pluriserialibus valde inæqualibus. *Tetradymia* (*Polydymia*) *ramosissima*, Torr. in Emory, Rep. (1848) p. 145. *Psathyrotes annua*, Gray, in Pl. Thurb. p. 323, & Mex. Bound. Surv. p. 102, quoad Pl. Thurb., Emory, etc.

PHALACROSERIS, Nov. Gen. *Cichoracearum.*

Capitulum pluriflorum. Involucrum campanulatum ecalyculatum, e squamis 12 – 16 lato-lanceolatis æqualibus biserialibus ima basi connatis. Receptaculum convexum nudum. Achenia conformia, breviter oblonga, subquadrata vel 4 – 5-costata, læria, disco epigyno magno: pappus nullus. — Herba Californica, glaberrima, *Troximi* facie; foliis lineari-lanceolatis seu oblanceolatis integerrimis cum scapis prossus nudis monocephalis e caudice perenni; capitulo ante anthesin erecto; floribus flavis.

PHALACROSERIS BOLANDERI. Westfall's Meadows, above Yosemite Valley, alt. 8,000 feet, [also collected by Dr. Torrey in 1865, specimens just received,] Bolander. Leaves tufted on the summit of the thickish caudex, 3 to 9 inches long, about 3 lines wide, rather soft, mostly obtuse. Scapes wholly leafless and naked, 6 to 14 inches high; the solitary head about the size of that of *Leontodon autumnale.* Scales of the involucre about half an inch long, rather herbaceous, lanceolati, acutish. Corolla with a short glabrous tube and an oblong-linear exserted ligule. Achenia a line and a half long, thickish, somewhat unequally 4 – 5-angled, very smooth, the broad naked apex truncate. — I know of no genus having a pappus with which this plant would readily associate.

CALAIS (SCORZONELLA) GLAUCA: 1 – 3-pedalis; ramis pedunculisve strictis sæpe validis fistulosis; foliis lanceolatis oblongisve acuminatis nunc integerrimis vel denticulatis nunc laciniatis; pappi paleis lanceolato- seu ovato-subulatis in aristam attenuatis. *Hymenonema?*

P. ANNUA (Gray, Pl. Wright. l. c.): furfuracea, cinerea; foliis deltoideo-dilatatis subreniformibus vel supremis cuneatis angulato-dentalis; involucri squamis lanceolatis; floribus luteis; acheniis oblongo-turbinatis; pappi setis paucioribus minus inæqualibus. *Bulbostylis* (*Psathyrotus*) *annua*, Nutt. Pl. Gamb. p. 179. — "Rocky Mountains near Santa Fe," Dr. Gambel, according to Nuttall; perhaps from further West, having now been rediscovered in the Sierra Nevada of California. Bolander's specimens accord with Nuttall's plant, which, however, wants the lower leaves; and the bristles of the pappus are less unequal, almost uniserial.

§ 2. Scaposæ, capitulis subcorymbosis nudis erectis. Involucri squamæ subconformes, interiores vix nervatæ haud deciduæ. Corollæ sursum subampliatæ, dentibus extus pilis paucis brevioribus viscosis præditæ. Styli rami longiores, extus hirtelli, apice obtuso. Achenia oblongo-turbinata, minus villosa. Pappi setæ valde inæquales.

P. SCAPOSA, Gray, Pl. Wright. l. c. t. 13.

P. incisa, Gray, Pl. Thurb. l. c. = *Trichoptilium incisum*, Gray in Bot. Mex. Bound. p. 97.

glaucum, Hook. Fl. Bor. Am. *Scorzonella glauca*, Nutt. — At Mark West's Creek, 1864; also Cloverdale, Sonoma Co., and Eel River, &c. Mendocino Co., in moist meadows, 1866 – 7, Bolander. The size of most of these specimens and the breadth of the leaves made it doubtful if they belong to the species indicated by Sir Wm. Hooker; but a comparison made by Prof. Oliver with the solitary specimen preserved in the Hookerian herbarium (the leaves of which are not "canaliculate" but only longitudinally folded) assures me that they do. The leaves in the California plant are from 4 to 12 inches long, and from 1 to 2½ wide, the midrib strong and broad. In specimens from Klamath Co., Oregon, Dr. Kronkrite, they are narrower, approaching to "linear-acuminate," and the head scarcely larger than in *S. laciniata*. In Bolander's, the larger heads are an inch in diameter; the achenia fully 2 lines, and the pappus nearly half an inch in length. The Californian forms in general, being remarkably stout and tall, and so broadly-leaved, may be distinguished as var. PROCERA.

CALAIS BOLANDERI: subscaposa e radice tuberoso-fusiformi; caulibus basi parce ramosis scapisve gracilibus 1 – 2-pedalibus; foliis lineari-lanceolatis elongatis integerrimis imisve subdentatis nunc laciniatis; capitulis parvulis ante anthesin nutantibus; involucri squamis gradatim imbricatis e lanceolata vel ovato-lanceolata attenuato-acuminatis; acheniis breviter linearibus (vix basi haud apice angustatis) glabris vel exterioribus puberulis; pappi sordescentis paleis 8 – 9 brevibus ovato-oblongis ex apice obtuso vel eroso-bidentato in aristam scabram achenio duplo longiorem productis. — Swamps at Fort Bragg, Mendocino Co., Bolander. — Leaves 8 – 14 inches long (including the tapering base or petiole), or those on the lower part of the stem 3 – 6 inches long, 3 to 6 lines broad, more commonly entire; some denticulate or coarsely toothed, or, in one specimen, laciniate-pinnatifid. Involucre scarcely over half an inch in length. Achenia rather slender, barely 2 lines long, about thrice the length of the somewhat rigid paleæ of the pappus. The species is interesting from being, as it were, intermediate between *Eucalais* and *Scorzonella*.*

HIERACIUM BOLANDERI: *H. venoso* affine; foliis omnibus radicalibus sessilibus spathulato-oblongis vel oblanceolatis vix denticulatis infra glaberrimis glaucescentibus (nunc purpureis) supra marginibusque pilis

* HYPOCHÆRIS GLABRA, Linn., occurs in collections made by Dr. Kellogg and Dr. Gibbons in the vicinity of San Francisco, perhaps recently introduced from Europe.

longissimis laxis barbatis; scapo filiformi (3–9-pollicari) cum capitulis 2–4 laxe corymbosis glaberrimis; involucro cylindraceo 10–15-floro eglanduloso biseriali, squamis exterioribus brevibus; ligulis flavis; acheniis fusiformibus apice leviter attenuato; pappo copioso sordido.— On Red Mountain, Humboldt Co., Bolander. Achenia 2 lines long, much longer than those of *H. Scouleri*, and fusiform, but less tapering upwards than those of *H. Gronovii*.

Campanula linnæifolia: fere glaberrima; caulibus teneribus a basi ad apicem usque æqualiter foliosis subunifloris; foliis ovalibus sessilibus (semipollicaribus) crenatis marginibus angulisque caulis setulis minimis retrorsis ciliolatis; pedunculo erecto flore sæpius longiore; calycis lobis lato-lanceolatis acutis tubo subhemisphærico duplo longioribus corolla campanulata vix ad medium 5-loba dimidio brevioribus; sinubus nudis; stylo incluso.—In swamps at Noyo, Mendocino Co., Bolander. A delicate little species. Corolla blue, half an inch long; the lobes ovate, about 2 lines long.

Campanula prenanthoides, Durand, Pl. Pratt. 1855 (evidently *C. filiflora*, Kellogg in Proceed. Acad. Calif., 1858, a far from appropriate name, and with a description which implies that the narrow corolla is barely 5-toothed, whereas it is really 5-parted in our specimens, the segments linear): to this probably belong specimens gathered by Mr. Bolander in the Red Woods at Searsville, and by Prof. Brewer on the Upper Sacramento, &c.

Arctostaphylos bicolor (*Xylococcus bicolor*, Nutt., *Comarostaphylis bicolor*, Klotsch): erecta; foliis coriaceis oblongis acutis breviter petiolatis integerrimis margine revolutis supra nitidis subtus cum racemis brevibus compactis ramisque junioribus incanis; bracteis sepalisque ovato-rotundis squamaceis; corolla obovato-urceolata; filamentis villosis inferne vix dilatatis; stigmate capitato crasso; putamine 5-loculari nunc abortu uniloculari.—Near San Diego, March, 1862, Dr. J. G. Cooper, from whose specimens this character is taken. Nuttall found it near Monterey, and describes the bony putamen as one-celled; but I find five one-seeded cells.

Arctostaphylos nummularia: erecta (1–2-pedalis), ramosissima; ramis cum petiolis brevissimis setoso-hirsutis; foliis crebris coriaceis (semipollicaribus) ovali-rotundatis nunc subcordatis nitidis venulosis muticis integerrimis raro mucronato-serrulatis; racemis parvis fasciculatis glabris; bracteis coriaceo-squamaceis pedicello dimidio brevioribus; sepalis ovato-rotundis; corolla ovato-globosa intus filamentisque glaber-

rimis; aristis antheræ prælongis genuflexis; ovario tomentuloso. — On the plains near Mendocino City. Leaves rounded at the apex and seldom with any sign of a mucro. Flowers much smaller than those of *A. tomentosa*, white. Fruit unknown.

BRYANTHUS, Gmelin. *Bryanthus* & *Phyllodoce* (Salisb.), Don. The beautiful Californian species described below makes it necessary to combine *Phyllodoce* with the far earlier *Bryanthus*. Among the characters to distinguish the genus from *Menziesia* are the foliaceous persistent bracts or leaves subtending the pedicels, as in *Kalmia*, &c., while Menziesia has strobilaceous flower-buds of scarious caducous scales, as in *Azalea*, &c.

§ 1. Corolla patenti-campanulata usque ad medium 5-fida; stamina exserta.

BRYANTHUS BREWERI: glaber; caulibus adscendentibus rigidis; foliis crebris linearibus lævibus margine arcte revolutis; pedicellis plurimis minute glandulosis flore vix longioribus; sepalis oblongo-ovatis glaberrimis; corolla rubro-purpurea; staminibus 10 (raro 7 – 8) styloque longius exsertis; antheris violaceis; stigmate capitato. — High sierras of California, alt. 10,000 feet; on Wood's Peak, Eldorado Co., Prof. Brewer; near Donner's Pass, Prof. Torrey; and Mariposa Co., Bolander: also Mt. Hoffmann, Brewer (forma compacta, floribus primum capitato-congestis). In habit and foliage this resembles the following species, but is larger, the leaves sometimes half an inch in length, stems nearly a foot high; the bright "rose-violet" or "red-purple" corolla half an inch in diameter when expanded, cleft to or rather beyond the middle. Anthers, as in the other species, opening by terminal chinks, but inclined to dehisce longitudinally.

§ 2. PHYLLODOCE. Corolla ore 5-dentata vel brevissime 5-loba, stamina includens,

* Campanulata, glabra, rosea, lobis reflexis: folia lævia margine revoluta.

BRYANTHUS EMPETRIFORMIS. *Menziesia empetriformis* (Smith) & *M. Grahamii*, Hook. This (*M. Grahamii*, Hook., which appears really to be the *M. empetriformis* also) was collected on Mount Shasta by Prof. Brewer. The style is either short-exserted or included on the same plant.

BRYANTHUS INTERMEDIUS, *Menziesia intermedia*, Hook., needs further elucidation. One specimen from Dr. Lyall's collection in the Rocky Mountains, with cylindraceous corolla, and narrower (but not

acuminate) sepals, leads to the conjecture that the species is not wholly distinct from the foregoing.

* * Corolla ore contracta: folia marginibus haud revolutis pl. m. serrulato- seu glanduloso-scabris: sepala lanceolata.

BRYANTHUS TAXIFOLIUS, having rose-colored or purple, rarely if ever blue flowers, had better have the Pallassian than the Linnæan name continued, that having been generally adopted under *Phyllodoce*.

BRYANTHUS ALEUTICUS (*Menziesia Aleutica*, Spreng., Bongard, pro parte, *Phyllodoce Pallassiana*, Don) is known by the glabrous filaments and (shorter, ochroleucous) corolla from

BRYANTHUS GLANDULIFLORUS (*Menziesia glanduliflora*, Hook.), which occurs in Sitcha. The former I have seen only from Unalaschka and Alaska.

ALLOTROPA, Torr. & Gray.

Perigonium simplex, quam genitalia brevius, e phyllis (ut videtur sepalis) 5 rotundatis æstivatione imbricatis. Stamina 10, glabra: antheræ didymæ, æquales, extrorsum fere basifixæ, loculis rima brevi a basi versus medium extensa dehiscentibus, sub anthesi arcte inversæ introrsum pendulæ, modo *Pyrolæ*. Discus nullus. Ovarium globosum, 5-loculare: ovula in placentis axilibus innumera. Semina immatura scobiformia, e nucleo undique longe producta linearia. Stylus primum brevissimus, demum ovario plus dimidio brevior: stigma majusculum, depresso-capitatum. Herba spithamæa, brunnea, glabra, caule squamis inferioribus ovatis imbricatis superioribus lanceolatis obtusis patentibus tecto, spica virgata multiflora, floribus brevissime pedicellatis patentibus parvulis, superioribus bracteas lanceolato-lineares adæquantibus.

ALLOTROPA VIRGATA, Torr. & Gray, in Bot. Wilkes Exped. ined. A single and imperfect specimen was collected by Dr. Charles Pickering on the Cascade Mountains in Oregon. We now have it from Mr. Bolander (in the usual excellent specimens which he is accustomed to prepare), collected in Mendocino County, between Little Bear Harbor and Noyo, "generally near *Quercus densiflora*." The characters of the proposed genus are briefly sketched in a synopsis of the known genera of *Monotropeæ* which I contributed to Prof. Newberry's Report, in Pacif. R. R. Survey, 6, Bot. p. 81. It was then supposed (from the examination of a single flower-bud) to be nearly related to *Monotropa*, section *Hypopitys;* but the character, it will be noticed, has now to be entirely recast, and the genus claims its relationship to

Schweinitzia and to *Pyrola.* The anthers of *Allotropa* in the expanded flower much resemble those of *Schweinitzia,* except that, in place of the large orifice occupying the whole broad end of each cell, a slit which opens broadly extends from the extremity to near the middle. In view of this resemblance, and of Dr. Torrey's observation (which I have confirmed) that the anthers of *Schweinitzia* in the flower-bud are horizontal, so that one cell stands directly over the other, one may suspect that here also they are extrorse and basifixed in the early bud; but I have no evidence that it is so. And the earliest flower-buds which I have examined of *Pterospora* and *Sarcodes* show no indication of resupination. Two subulate bractlets which were thought to have been detected upon the original specimen of *Allotropa* are not seen in the good specimens now in hand. I presume that its simple perianth answers to the calyx of *Schweinitzia,* and that the corolla is wanting.

PLEURICOSPORA, Nov. Gen. *Monotropearum.*

Perigonium duplex completum. Sepala 4 – 5, oblongo-lanceolata, petalis totidem discretis oblongis subconformibus alterna et dimidio breviora, utraque (supra medium præsertim) margine laciniato-fimbriolata. Genitalia petalis breviora, glabra. Stamina 8 vel 10: antheræ lineares, innatæ, filamento filiformi complanato vix latiores, callo brevi retuso apiculatæ, loculis rima laterali leviter introrsa a basi ad apicem dehiscentibus, valvis fere æqualibus. Discus nullus. Ovarium ovatum in stylo crasso æquilongo attenuatum, uniloculare, placentis 4 – 5 parietalibus bilamellatis undique ovuliferis. Stigma depresso-capitatum. Ovula obovata. Capsula . . . . Semina ovalia, nitidula, testa nucleo conformi. — Herba glabra, 3 – 5-pollicaris, sæpius crassa; squamis confertis imbricantibus, infimis ovatis margine erosulis, superioribus floralibusque ovato-lanceolatis margine scariosis eroso-fimbriolatis; spica sæpius cylindrica dense multiflora; floribus ut videtur albidis semipollicaribus bracteam adæquantibus.

PLEURICOSPORA * FIMBRIOLATA. — In or near the Mariposa *Sequoia gigantea* Grove, Bolander, sparingly collected. This interesting plant is most allied to the one which, in Newberry's Report, above cited, I described and had figured under the name of *Hemitomes congestum,* and which, as this generic name, given upon a wrong idea of mine as to the structure of the anther, is contradicted by the true character,

* The generic name alludes to the parietal placentation.

Dr. Torrey, in making the rectification, proposes to call *Newberrya*, in honor of the distinguished vegetable palæontologist and geologist who discovered it. The principal differences between these two genera appear in the subjoined synopsis. That of the seven genera of the group, all but the Linnæan one should rest upon single species, is not altogether satisfactory to contemplate; but their characters are so marked that it does not seem possible to combine any two of them.*

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* CONSPECTUS GENERUM MONOTROPEARUM.

Tribus I. EUMONOTROPEÆ. Ovarium 4 – 5-loculare, placentis axilibus in columnam crassam concretis. Testa seminum laxa reticulata.

§ 1. Corolla nulla. Calyx 4 – 5-sepalus. Antheræ in alabastro extrorsæ basim versus rimis brevibus dehiscentes, sub anthesi inversæ introrsum pendulæ. Semina scobiformia. Nexus cum *Pyroleis* mediante *Pyrola aphylla*.

1. ALLOTROPA, Torr. & Gray, supra.

§ 2. Corolla gamopetala. Calyx 4 – 5-sepalus. Antheræ introrsæ,

* Muticæ, apice foraminibus hiantes. Corollæ campanulata, 5-loba. Testa seminum nucleo subconformis.

2. SCHWEINITZIA, Ell. Antheræ breves, didymæ, in alabastro transversæ, sub anthesi introrsum pendulæ. Discus 10-crenatus. Stylus brevis crassus.

3. SARCODES, Torr. Antheræ lineari-oblongæ, erectæ, supra basim affixæ. Discus nullus. Stylus elongatus.

** Antheræ introrsum pendulæ, dorso biaristatæ, longitrorsum dehiscentes. Corolla ovata, 5-dentata. Semina scobiformia apice insigniter alata.

4. PTEROSPORA, Nutt.

§ 3. Corolla 4 – 5-petala, petalis basi gibbosis vel saccatis. Calyx imperfectus, e bracteolis sepalisve 2 – 5. Antheræ innatæ, didymæ vel reniformes, confluentim uniloculares, ab apice transversim bivalves. Discus e dentibus 8 vel 10 deflexis. Semina scobiformia.

5. MONOTROPA, Linn. (*Hypopitys*, Dill.)

Tribus II. PLEURICOSPOREÆ. Ovarium uniloculare: placentæ 4 – 5 parietales, bicrures vel bipartitæ. Testa seminum tenuis nucleo arcte conformis. Discus nullus. Antheræ innatæ, oblongo-lineares, biloculares, loculis parallelis longitudinaliter bivalves. Stylus elongatus.

6. PLEURICOSPORA. Calyx completus, e sepalis 4 – 5 petalis discretis subconformibus, utrisque fimbriolatis. Genitalia glabra. Antheræ lateraliter dehiscentes in valvibus fere æqualibus. Flores spicati.

7. NEWBERRYA, Torr. in Ann. Lyc. N. Y. 8, p. 7, 1864. (*Hemitomes*, Gray, nomen falsum.) Calyx incompletus, disepalus, bracteoliformis. Corolla gamopetala, urceolato-tubulosa, 4 – 5-loba, lobis intus villosulis. Filamenta filiformia stylusque superne villoso-crinita. Antheræ introrsum dehiscentes, loculis inæqualiter bivalvibus. Flores capitati. — NEWBERRYA CONGESTA, Torr. = *Hemitomes congestum*, Gray.

DOUGLASIA MONTANA: subglabra; foliis secus ramos imbricatis subulato-linearibus acutiusculis glabris ciliolatis; floribus plerisque solitariis; calyce basi vix truncato unibracteato, segmentis acutissimis tubo paullo longioribus corollæ tubum adæquantibus. — Rocky Mountains, Montana Terr., Winslow J. Howard, M. A. Brown. Nearer to *D. arctica* than to *D. nivalis*. To *Douglasia* belongs *Gregoria*, Duby, apparently founded in the same year, Lindley referring to Brande's Journal of January, 1828, for his original character of *Douglasia*. But it is really in the volume for 1827, which gives this name a clear priority.

PRIMULA SUFFRUTESCENS: cæspitosa, glabra; caudicibus elongatis humifusis incrassatis sublignosis; foliis confertissimis spathulato-cuneatis basi longe attenuatis apice 5–9-dentatis crassis fere aveniis; scapo foliis 2–3-plo longiore 3–7-floro; involucri foliolis lineari-subulatis pedicellis brevioribus; calyce minutim glanduloso (cum pedicellis), segmentis lato- seu ovato-lanceolatis tubo brevissimo duplo longioribus corollæ rubro-purpureæ tubo subdimidio brevioribus; lobis corollæ leviter obcordatis. — California, Lobb, in herb. Hook. Sierra Nevada, on Silver Mountain, alt. 10,500, near the snow, Brewer. Leaves about an inch long, resembling those of *Saxifraga cuneifolia*, but narrower and thicker. Lobes of the calyx varying from lanceolate to almost ovate. Corolla about half an inch long.

PLANTAGO HIRTELLA, HBK., var. CALIFORNICA (*P. Urvillei*, var. *Californica*, Fisch.), occurs along the coast at Monterey and San Francisco, and, more interior, at Los Angelos (Dr. Peckham). It accords very well with Fendler's Pl. Venez. No. 768, and perhaps was introduced into California.

PHELIPÆA TUBEROSA: nana, superne pruinoso-puberula; caule basi tuberoso-incrassato squamis strobilaceis imbricantibus tecto superne breviter confertissime ramoso densifloro; calyce bibracteolato profunde inæqualiter 5-fido (sinubus 2 anticis fere ad basim usque, lateralibus et posticis ultra medium extensis), segmentis æquilongis lanceolatis corolla lutescente tubulosa paullo brevioribus; antheris glabris vel ad suturas parce lanigeris. — On a high and dry ridge of the Gavilan Mountains, in sandy soil, Brewer. A span or less in height; the much-crowded flowers barely half an inch in length. Nearly related to

PHELIPÆA PINETORUM (*Orobanche pinetorum*, Geyer in Hook. Kew Jour. Bot. 3, p. 297): caule ramisque pubescentibus; squamis inferioribus angustioribus; calyce vix ad medium æqualiter 5-fido, lobis subulatis. — Char. from fructiferous specimen collected in the valley of the Columbia by Dr. Lyall, comm. Royal Gardens, Kew.

PHELIPÆA ERIANTHERA, Engelm. MSS. (*Orobanche multiflora* Nutt. Pl. Gamb. p. 179, ex char.): *P. Ludovicianæ* peraffinis; floribus majoribus; antheris crassioribus maxime lanigeris; calycis segmentis vulgo gracilioribus. — New Mexico, Fendler (585), Wright (1449, anthers less woolly), J. M. Bigelow, Parry (147, coll. 1867); Pachitiga, Chihuahua, Thurber, cited in Bot. Mex. Bound. Survey as *P. Ludoviciana.* Apparently a quite distinct species, but the woolliness of the anthers must not be too implicitly relied on.

* ANTIRRHINUM, Tourn.

On a survey of our North American species, which in California are now rather numerous, it seems inevitable that *Antirrhinum* should include the personate species of *Maurandia,* also Nuttall's *Gambelia.* I propose the following arrangement: —

§ 1. ORONTIUM, Benth. — I have seen no indigenous species.

A. CYATHIFERUM, Benth., by the description, and still more by the figure, has a rather prominent palate to the ringent corolla.

A. CONFERTIFLORUM, Benth., from Coulter's collection, I suspect to be *Mohavea viscida,* which is No. 616, in fruit only, in Coulter's Californian collection.

§ 2. SÆRORHINUM. Corolla palato prominente extruso faucem haud vel vix claudente. Filamenta apice pl. m. dilatata. Capsula inæqualis. Semina *Antirrhinastri.* — Herbæ annuæ, Californicæ, plerumque alternifoliæ, nunc strictæ, nunc diffusæ et ramulos filiformes sæpe prehensiles proferentes. Pedicelli breves vel subnulli. Flores sæpissime parvi.

A. glandulosum and *A. Virga* are the species in which the palate is most appressed to the upper lip. In the diffuse species the corolla more and more approaches that of the following section. Their slender branchlets, mostly produced from the same axil with a flower, are evidently sensitive to contact in the same manner as the petioles and peduncles of *Maurandia.* In specimens of *A. vagans* and *A. Breweri* they are not rarely found with one or two close turns around some slender object, and the coil thickened and hardened in the manner of most petiole-climbers. The similar twining branches of the erect and spicate *A. Coulterianum* have been noticed by Dr. Parry or Prof. Thurber. A case of special interest, as a step in the transition from leafy branch to tendril, occurring in a genus of which some species do not climb at all, while others climb by tendril-like petioles and peduncles.

* *Axilliflora;* axillis fere a basi ad apicem caulium simplicium vel basi simpliciter ramosorum floriferis sine ramulo. Folia oblongo-linearia, obtusa, subpetiolata, conformia, flores parvos brevissime pedicellatos plerumque superantia. Calyx subæqualis, segmentis linearibus. Capsula stylo rigido subulato superata. Caulis erectus, strictus.

ANTIRRHINUM CORNUTUM, Benth. Pl. Hartw.: viscoso-villosum, subglandulosum; caule subpedali basi ramoso; corollæ tubo calyce labiisque suis longioribus, sacco prominente scrotiformi; filamentis omnibus apice oblique obovato-dilatatis; stylo capsula parum longiore; seminibus echinulato-favosis. — Known as yet only from Hartweg's No. 1888, from the valley of the Sacramento.

ANTIRRHINUM LEPTALEUM: viscoso-villosum, fere eglandulosum; caule sesquipedali simplicissimo vel basi parce ramoso; corollæ ut videtur albæ tubo calycem vix superante labiis (superiori alte bifido) subæquilongo, lobis fere æqualibus obovatis leviter eroso-crenulatis, sacco angusto scrotiformi; filamentis longioribus apice oblique obovato-dilatatis, brevioribus vix dilatatis; stylo capsulæ subæquilongo; seminibus rugoso-foveolatis. — Mariposa Co., at Clark's Ranch, Bolander. Flowers shorter and more crowded than in *A. cornutum;* the tube only 2 or 2½ lines long. Leaves at most an inch long.

* * *Spicata;* floribus folia floralia diminuta superantibus densius spicatis. Folia angusta, pleraque sessilia. Caules erecti ramosi, in sp. ultima ramulis prehensilibus instructi.

ANTIRRHINUM VIRGA: glaberrimum; caule simplicissimo stricto (ultrabipedali); foliis caulinis angustissime linearibus suberectis (imis ignotis), floralibus parvis subulato-setaceis calycem adæquantibus; racemo spiciformi virgato densifloro (subpedali); floribus secundis mox horizontalibus; corollæ tubo labiis calycisque segmentis vix inæqualibus ex ovato-lanceolata subulatis duplo longioribus, sacco mammæformi, palato barbulato, lobis brevissimis; filamentis viscoso-hirsutis, longioribus præsertim apice dilatato anthera latioribus. — California, No. 191, in collection of the late Thomas Bridges, distributed by the Smithsonian Institution. Lowest leaves of the specimen about 1½ inches long, barely a line wide, tapering upwards. Corolla seemingly white or whitish, half an inch long, the tube cylindrical. The fruit of this very peculiar species not seen.

ANTIRRHINUM GLANDULOSUM, Lindl.: elatum, undique pilis glandulosis viscosissimum, late ramosum; foliis lanceolatis, floralibus flore paullo brevioribus, racemo spiciformi itaque folioso; corollæ roseæ tubo

lato labiis æquilongis calycisque segmentis inæqualibus lato-lanceolatis paullo longioribus; filamentis conformibus sursum leviter dilatatis; stylo longo; seminibus fimbrillato-favosis. — Apparently very common around Santa Barbara, Santa Cruz, Santa Clara, &c. No filiform branches accompanying the flowers; these over half an inch in length.

ANTIRRHINUM COULTERIANUM, Benth.: caule gracili 2 – 4-pedali glaberrimo erecto vel ope ramorum prehensilium sustento; foliis glabris linearibus vel inferioribus oblongis subpetiolatis, floralibus minutis; racemo spiciformi conferto viscoso-piloso sæpius glanduloso; corollæ tubo calycis segmentis paullo longiori, sacco mammæformi magno, labio inferiori maximo tubo duplo longiori, superiori parvo patentissimo bifido; filamentis sursum dilatatis; stylo persistente capsula dimidio breviore; seminibus foveolatis. — Found only in the southern part of California. "Stem supporting itself on other plants by its twining slender branches." Some of these appear in the raceme, from the same axils with the lower flowers, are tendril-like, flexuous or spirally incurved; the minute leaves at their apex also recurved, forming hooks.

* * * *Axilli-ramulosa;* floribus secus ramos diffusos sparsis, axillis floriferis sub flore sæpius ramulo filiformi nunc tortili prehensili instructis. Folia petiolata, flore plerumque longiora. Calyx inæqualis, sepalo postico majore.

+ Pedunculi calyce longiores: filamenta sursum sensim dilatata.

ANTIRRHINUM NUTTALLIANUM, Benth.: viscoso-pubescens; foliis ovatis imisve subcordatis, floralibus superioribus flore brevioribus; calycis segmentis subovatis, postico fere enervi cæteris modice majoribus tubo corollæ violaceæ paullo brevioribus; labiis tubo longioribus, superiore suberecto emarginato-bilobo palatum adæquante; seminibus longitudinaliter undulato-costatis. (*Sairocarpus Californicus*, Nutt., in herb.) — Collected apparently only near San Diego and Los Angeles, by Coulter, Nuttall, Wallace, and Dr. Cooper. — Flower 4 or 5 lines long.

+ + Pedunculi calyce breviores: filamenta apice oblique spathulato-dilatato. Calyx pilis longis laxis hirsutus.

ANTIRRHINUM BREWERI: tenuiter viscoso-pubescens; ramis gracillimis dissite floriferis; foliis ovato- seu oblongo-lanceolatis obtusiusculis, superioribus retusis, summis flore brevioribus; calycis segmentis linearibus seu lineari-lanceolatis, postico parum latiori tubo corollæ paullo breviori subuninervi; corollæ pallide violacea, labio superiori

parvo fere bipartito, lobis oblongis divergentibus; seminibus inordinate tuberculatis. — Upper Valley of the Sacramento, south of Mount Shasta, Brewer. Lake County, Torrey. Mount Bullion, Mariposa County, Bolander.

Var. OVALIFOLIUM: foliis ovalibus retusis, superioribus emarginatis, ramealibus parvis orbiculatis; calyce breviore, segmentis oblongis. With Prof. Brewer's specimens from the Upper Sacramento. — Larger leaves about an inch long, including the petiole. Flower 5 or nearly 6 lines long; lower lip, with its very prominent palate and oval lobes, very much larger than the upper.

ANTIRRHINUM VAGANS: pilis patentissimis rigidulis interdum glandulosis hirsutum, nunc glabratum; foliis lanceolatis oblongisve, ramealibus nunc linearibus nunc orbiculatis; calycis segmentis valde inæqualibus, postico angusto- seu lato-oblongo obtusissimo 3 – 5-nervi corollæ tubo æquilongo, cæteris linearibus; corollæ purpureæ? sacco amplo, labio superiori bilobo palatum adæquante; seminibus inordinate tuberculatis. — Near San Francisco, valley of the Upper Sacramento, and other parts of California, collected by Fremont, Brewer, Bolander, Torrey, Heermann, &c. Also a very glandular-hirsute form by the late Mr. Bridges. Flowers from 6 to 8 lines long, sometimes much scattered, often rather crowded and racemose or spicate at the upper part of the branches.

Var. BOLANDERI: floribus in axillis valde remotis; foliis superioribus orbiculatis vel subcordatis; calycis maxime inæqualis segmento postico late ovali. — In the Redwoods, Marin County, Bolander. This variable species, and especially the variety here indicated, well shows the cirrhose character of the slender branchlets, which frequently hook or coil with one or two turns around some slender object, the coil thickening and hardening as in analogous cases.

§ 2. MAURANDELLA. (*Maurandiæ* sp. personatæ.) Corolla palato prominente faucem vix ac ne vix claudente. Filamenta sursum vix ampliata. Capsula fere æqualis. Semina fere *Antirrhinastri*. — Herbæ pedunculis petiolisve flexuosis vel cirrhiformibus sæpius scandentes, foliis plerisque alternis.

* Herbæ annuæ, pedunculis elongatis tantum scandentes vel erectæ, basi pilosæ, cæterum glabræ; foliis integris, petiolis brevibus rectis vel subnullis.

A. STRICTUM (*Maurandia stricta*, Hook. & Arn., Benth.): caule erecto 1 – 2-pedali; foliis lanceolatis, floralibus linearibus; pedunculis

filiformibus flexuosis dissite racemosis; corolla violacea semipollicari, palato piloso; capsula ovoideo-globosa crustacea stylo longo rigido superata calycis segmentis lato-lanceolatis paullo longiore; seminibus rugoso-muricatis. — Near Santa Barbara, Douglas; a very slender and strict, small-leaved form. Very dry hillside, Santa Inez Mountains, Santa Barbara, March, 1861, Brewer; more robust and leafy: leaves $1\frac{1}{2}$ to $2\frac{1}{2}$ inches long, many of the lower fully half an inch wide, contracted at base into a distinct petiole of half an inch in length: branches developing in many of the axils. The tortuous peduncles, about 2 inches long, evidently become prehensile upon occasion.

ANTIRRHINUM FILIPES, Gray (in Ives Colorado Exped. Bot. p. 19): tenellum, diffusum; foliis lanceolatis imisve obovatis repandis in petiolum attenuatis; pedunculis capillaribus prælongis cirrhoso-tortilibus; floribus parvis "albis"; capsula globosa. — Desert arroyos of the Colorado, Dr. Newberry. Specimen imperfect. Allied to the next: but the flowers seem to be very small, and are said to be white.

ANTIRRHINUM COOPERI: gracile, ramosissimum, scandens; foliis linearibus seu lineari-lanceolatis in petiolum breve attenuatis; pedunculis capillaribus cirrhosis, superioribus secus ramos filiformes nudos racemosis; corolla flava semipollicari, palato amplo piloso faucem subclaudente; capsula globoso; seminibus ventre ruguloso-muriculatis dorso costis 3–4 crassis suberosis instructis. — Gravelly ravine near Fort Mohave, Feb. 27, 1861, Dr. J. G. Cooper. "Twining 3–4 feet high." Peduncles 2 or 3 inches long, coiling freely.

* Herbæ petiolis pedunculisque prehensilibus scandentes; foliis cordato-hastatis angulatis; radice perenni.

ANTIRRHINUM MAURANDIOIDES = *Maurandia antirrhiniflora*, Willd. — Texas, Arizona, Mexico.

§ 3. GAMBELIA. (*Gambelia*, Nutt. Pl. Gamb., in Jour. Acad. Philad. ser. 2. 1, p. 149.) Corolla tubulosa basi leviter gibbosa, palato prominulo faucem non claudente, labiis brevibus, postico erecto bifido, antico lobis 3 patentibus. Filamenta sursum vix ampliata. Capsula æqualis. — Frutices vel suffrutices Austro-Californici, erecti, foliis oppositis vel ternato-verticillatis passim subalternis integerrimis, summis diminutis. Pedunculi axillares, longiusculi.

ANTIRRHINUM SPECIOSUM = *Gambelia speciosa*, Nutt. l. c. Catalina Island, Dr. Gambell. Leaves oval or oblong, an inch or less in length, and with a short petiole, not unlike those of *A. latifolium*. Corolla almost an inch long, said to be "scarlet," apparently rather pink-red, the narrow tube thrice the length of the lips.

ANTIRRHINUM JUNCEUM = *Mauraudia juncea*, Benth. Bot. Voy. Sulph. p. 41. From San Diego to the Bay of Magdalena, Hinds. — I have not seen this; but it seems to be a congener of the last, but with smaller flowers and leaves, the uppermost reduced to minute scales. The seeds as described are those of *Antirrhinastrum*.

MAURANDIA, Ort.

This genus, relieved of the section *Antirrhiniflorœ* Benth., and connected through the wing-seeded *M. Wislizeni* with *Lophospermum*, now secures more definite characters.

§ 1. EUMAURANDIA. (*Maurandiœ Galvesiœflorœ*, Benth.) Semina tuberculata, aptera. Calyx fructifer stylusque fere immutati, segmentis angustis.

M. BARCLAYANA, Lindl. — Calyx insigniter glanduloso-pilosus, segmentis longe attenuatis.

M. SEMPERFLORENS, Ort. — Calyx glaberrimus, brevior.

§ 2. EPIXIPHIUM, Engelm. Semina ala integerrima cincta. Calyx fructifer auctus, coriaceus, basi 5-angulatus, segmentis triangulari-lanceolatis valde reticulatis. Capsula stylo toto indurato subulato superata, loculis rima ex apice dehiscentibus.

M. WISLIZENI, Engelm., Gray in Bot. Mex. Bound. p. 111.

§ 3. LOPHOSPERMUM. (*Lophospermum*, Don.) Semina ala lacera seu irregulari cincta. Calycis segmenta foliacea, fructifera stylusque immutata.

M. ERUBESCENS = *Lophospermum erubescens*, Zucc.

M. SCANDENS (nec Pers.) = *L. scandens*, Don. An præcedentis var.

MOHAVEA, Gray.

Calyx 5-partitus, segmentis lanceolatis fere æqualibus. Corolla personata; labiis amplissimis obovato-flabelliformibus campanulato-suberectis vel patentibus tubo basi hinc gibbo multo longioribus, inferiore breviter trilobo, superiore bilobo, lobis eroso-subdentatis sæpius acutatis, palato prominente (quoad labium parvo) medio barbato. Stamina 2 antica fertilia, antheris confluenti-unilocularibus: filamenta 2 postica abortiva. Stigma depresso-capitatum. Ovarium, stylus, capsula (subæqualis) *Antirrhini*, semina hinc cyathifera § *Orontii*. — Herba annua, erecta, simplex vel laxe ramosa, viscido-pubescens; foliis lanceolatis in petiolum attenuatis, superioribus alternis; floribus axillaribus paucis subracemosis; corolla ampla luteola intus purpureo-punctata.

M. VISCIDA, Gray in Bot. Whippl. (Pacif. R. R. Exped. 4) p. 66, in Ives, Colorado Exped. Bot. p. 19. — In addition to the imperfect specimens gathered by Coulter, Bigelow, Newberry, &c., we now have it with both fine flowers and mature fruit, collected by Dr. J. G. Cooper, February 18, 1861, in a gravelly ravine at Fort Mohave. The specimens mostly do not exceed a span in height; but it is noted that the plant attains the height of two feet. The flower is fully an inch and a half in length. As already stated, I suspect *Antirrhinum confertiflorum*, Benth., may be founded upon an imperfect specimen of this remarkable plant; yet the flowers are not subsessile, nor the calyx-segments shorter than the tube of the corolla.

TONELLA COLLINSIOIDES, Nutt., taken up by Benth. in DC. Prodr. 10, p. 593, as *Collinsia tenella*, — having solitary ovules, corolla scarcely gibbous at the base and with an open limb, with the sinuses between the two lateral and the lower (explanate) segment rather deeper than on the posterior side, — may fairly claim the generic rank. Bolander collected it in Mendocino County.

COLLINSIA TORREYI: caule tenello ramosissimo superne cum pedicellis calyceque glandulosis; foliis glabris linearibus subdenticulatis basi attenuatis, floralibus superioribus minimis vel obsoletis; pedicellis quasi verticillato-racemosis calyce duplo longioribus; calycis segmentis lanceolato-oblongis obtusis corollæ labiis inæquilongis plus dimidio brevioribus. — Mariposa, Big-tree Grove, and near Donner Lake, Dr. Torrey. At Clark's Ranch, Bolander. A span high, the cauline leaves 1½ inches long. Verticillastri 4 - 6-flowered, mostly in a naked raceme. Corolla blue, about as large as in *C. parviflora*, but the calyx very much shorter, only about one third the length of the lower lip, which moderately exceeds the upper. I name it for the earlier discoverer, that it may be one of the permanent memorials of our oldest active botanist's visit to California, and to the "Mammoth Grove," in the shade of which this delicate little plant grows.

COLLINSIA CORYMBOSA, Hortul. (I know not the origin of the name, which is less appropriate than *capitata* would be), a depressed species, with rounded leaves, almost capitate inflorescence, broad calyx-lobes, and extremely short upper lip of corolla, was collected by Bolander on the coast at Fort Bragg, Humboldt Co.

COLLINSIA SOLITARIA, Kellogg, in Proceed. Acad. Calif. 2, p. 10. Depauperate specimens collected by Prof. Brewer, in April, in Marin Co., remarkable for their *ovate calyx-lobes*, equalling the broad tube of

the corolla, evidently are of this species. Dr. Brewer notes that the tube of the calyx is rose-colored, while the lobes are green. According to Dr. Kellogg, not only the calyx-tube, but also the peduncles, are bright purple. According to Dr. Brewer, the corolla is dotted with brown spots, the upper lip light yellowish.

Pentstemon Palmeri (inter *P. Jamesii* et *Cobæam*): sesquipedalis; foliis lanceolato-ligulatis argute denticulatis cauleque glaucescentibus, superioribus semiamplexicaulibus, inferioribus spathulatis in petiolum attenuatis; panicula nuda racemiformi virgata laxiflora glanduloso-puberula; bracteis minimis; pedunculis 2–3-floris; pedicellis gracilibus; sepalis ovatis glabriusculis; corolla pollicari pallide purpurea supra calycem latissime campanulato-ampliata, ore hiante, labio inferiore intus hirsuto; filamento sterili leviter exserto apice incurvo insigniter flavo-barbato. — Arizona, in Skull Valley, and on Rio Verde, near Fort Whipple, Drs. Elliott Coues and Edward Palmer. A well-marked species, with sterile filament bearded in the manner of *P. cristatus*, and corolla even more dilated in proportion than that of *P. Cobæa*.

Pentstemon Bridgesii (*Saccanthera*): præter inflorescentiam glaber; caule erecto 1–2-pedali; foliis integerrimis spathulato-lanceolatis linearibusque, caulinis sessilibus; panicula virgata racemosa, pedunculis 2–5-floris; sepalis ovato-oblongis acuminatis cum pedicellis æquilongis viscoso-pubentibus; corolla coccinea (pollicari) cylindraceo-tubulosa sursum leviter ampliata, fauce nuda, labio superiore erecto apice bilobo, inferiore tripartito, lobis recurvis oblongis tubo 2–3-plo brevioribus; filamento sterili nudo apice complanato; antheris quasi sagittatis apice solum dehiscentibus (rima hirtello-denticulata), loculis deorsum maxime productis diu parallelis. — No. 218 in Californian collection of the late Thomas Bridges. Yosemite Valley, very scarce, Bolander. A handsome and very interesting new species, having the anthers most distinctly of the section *Saccanthera*, but the habit and corolla of the section *Elmigera*. In cultivation it would rival *P. barbatus* and its allies.*

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* To the *Cheloneæ* there is apparently to be added a new genus, namely,

BERENDTIA, nov. gen. *Chelonearum* post *Leucocarpum*.

Calyx tubuloso-campanulatus, subangulatus, fere æqualiter 5-dentatus. Corolla infundibuliformis, bilabiata, labiis patentibus subæqualibus, superiore bilobo, inferiore trilobo, lobis brevibus rotundatis. Stamina 4, didynama, absque rudimento

MIMULUS MONTIOIDES: pusillus (semi-tripollicaris), glaber; radice annua; foliis linearibus seu lineari-spathulatis basi attenuata sessilibus integerrimiis subtrinervibus pedunculos sæpissime adæquantibus vel excedentibus, imis nunc oblongis; calycis oblongi dentibus brevibus æqualibus, ore recto; corolla aurea nunc fauce purpureo-guttata calyce 2-3-plo longiore (lin. 6-9 longa, limbo amplo), nunc pallidiora parva calyce paullo longiore. — High sierras of Fresno Co., Prof. Brewer. Near Carson City, Nevada, Dr. C. L. Anderson. Near Empire City, Nevada, Dr. Torrey. Mono Pass, Bolander. The latter of the small-flowered variety, which apparently was also collected in the Rocky Mountains of Colorado by Dr. Parry.

MIMULUS INCONSPICUUS (Gray in Bot. Whippl., char. reform.): glaber, erectus, 2-6-pollicaris e radice annua; foliis ovatis fere integerrimis 3-5-nervatis sessilibus pedunculos sæpius adæquantibus; calyce prismatico, fructifero oblongo pedunculo æquilongo, ore recte truncato, dentibus seu denticulis brevissimis æqualibus; corolla rosea vel purpurea (3-5 lin. longa) calyce sesqui vel bis longiore. — Larger specimens than those of Dr. Bigelow, collected near Monte. Diablo by Prof. Brewer, in Placer Co., by Mr. Rattan, along with a still larger form, No. 199 of Bridges' collection recently distributed by the Smithsonian Institution, enable me to give a better character to the species.

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quinti: filamenta filiformia exserta: antheræ biloculares muticæ. Stylus filiformis exsertus: stigma bilamellatum. Capsula loculicida, valvis integris medio septiferis placentas auferentibus. Semina numerosissima, parva: testa nucleo conformis. Suffrutices Mexicani, scabrido- vel glanduloso-pubentes; foliis oppositis subsessilibus rugoso-venosis; pedunculis axillaribus brevibus aut unifloris plerumque bibracteatis aut trifloris; corolla ampla purpurea vel rubra. (Char. carpologica e *B. Coulteri.*)

BERENDTIA GHIESBRECHTII: foliis obovato-oblongis basi cuneata integerrima ultra medium crenato-dentatis; pedunculis sæpissime unifloris; calycis dentibus subulatis tubo 2-3-plo brevioribus; corollæ tubo (pollicari) limbo suo calyceque triplo longioribus; stigmatis lobis lineari-oblongis; antheræ loculis divergentibus. — Chiapas, Ghiesbrecht, Dr. H. Berendt (an indefatigable explorer of the archæology and natural history of Mexico, to whom the genus is dedicated). Flower, including the exserted genitalia, 1½ to nearly 2 inches long.

BERENDTIA COULTERI: foliis oblongis seu obovatis fere integerrimis basi minus angustatis; pedunculis sæpius 3-5-floris; calycis dentibus latioribus tubo dimidio brevioribus; corollæ tubo e calyce vix exserto, limbo amplo; antheris subsaggitatis; stigmatis lobis ovalibus. — Mexico, No. 1334, 1335, coll. Coulter, ex herb. Trin. Coll. Dubl. — Limb of the corolla half an inch in width.

BERENDTIA RUGOSA = *Diplacus rugosus*, Benth. in DC. Prodr. 10, p. 368, is a congener of the above, fide Benth. in litt.

MIMULUS BOLANDERI: tenuiter viscoso-pubescens; caule e radice annua gracili simplicissimo (semi- vel subpedali) stricto a basi fere florifero; foliis oblongo- seu ovato-lanceolatis sessilibus fere integerrimis parvis (lin. 7 – 9 longis); floribus subsessilibus; calycis ovati plicati dentibus inæqualibus, postico dimidio longiore corolla (ut videtur rosea limbo brevi) paullo breviore; capsula subulato-fusiformi. — Dry hill-sides, at Clark's Ranch, Mariposa Co., Bolander. Corolla about 9 lines long, with included tube, funnel-form throat, and apparently very short ascending lobes. Calyx-teeth almost as in *M. brevipes*, but rather broader. Nearly allied to that species, but apparently distinct. It begins to flower, like an *Eunanus*, from the axils of the lower leaves.

EUNANUS COULTERI, Benth., Gray in Bot. Whippl. p. 64 (120), var. ANGUSTATUS: tubo corollæ sesqui – bipollicaris calycem sexies ad octies, folia linearia triplo quaduplove excedente. — Placer and Plumas Counties, Rattan, Bolander.

EUNANUS BICOLOR: viscido-puberulus; foliis oblongo-lanceolatis, imis spathulatis; calycis dentibus e basi lata angustato-lanceolatis fere æqualibus tubo oblongo-campanulato dimidio brevioribus; corollæ aureæ fauce lato-infundibuliformi atropurpurea, lobis æquilongis, tubo calyce subduplo longiore; stigmate lato-infundibuliformi integerrimo. — In the sierras between King's and Kawiah Rivers, Prof. Brewer. Plant about an inch high. Corolla from half to two thirds of an inch long.

CORDYLANTHUS, Nutt., Benth. (*Adenostegia*, Benth. olim.)

Calyx 1.– 2-phyllus, spathaceus, phyllis anticis et posticis nervatis integerrimis vel postico emarginato raro apice bifido. Corolla tubulosa, sursum leviter ampliata: labia brevia, fere semper æquilonga, inferius latum obtusissime 3-crenulatum: galea recta, apice breviter quasi uncinata. Stamina *Orthocarpi*. Antheræ loculi aut piloso-ciliati aut basi apiceque barbulati. Stylus apice sæpius uncinato-inflexus, sub stigmate integerrimo terminali incrassatus. Ovula plura, adscendentia, fere orthotropa, apice rostellata seu apiculata, rostello mox inflexo, vel campylotropo-reniformia. Capsula compressa, loculicida. Semina pauciuscula vel plura, nucleo ratione testæ parva, angusta, subrecta, apiculata: radicula supera. — Herbæ annuæ, ramosæ, angustifoliæ, floribus apice ramorum capitatim spicatim aut paniculatim congestis flavidis vel sordido-purpurascentibus.

§ 1. ADENOSTEGIA. Anthela composita. Flores sæpe breviter pedicellati, 2 – 4-bracteolati, calyce diphyllo instructi, phyllo vel sepalo

antico æstivatione exteriore. Folia floralia et bracteæ apice (*C. laxifloro* excepto) sæpissime truncatæ retusæ vel subtridentatæ callo glandulæformi pl. m. manifesto instructæ.

* Calyx phyllo antico sub-5-nervi, postico subscarioso binervi bifido. Stamina 2: filamenta fere glabra: antheræ biloculares. Folia floralia trifida vel subpinnatifida.

CORDYLANTHUS CAPITATUS, Nutt. Appears to have been found only by Nuttall. I possess a short flowering branch, on which I can confirm the characters assigned by Bentham, and add that the posterior division of the calyx is only 2-nerved (the nerves distant and running to the apex of the lobes), as in no other known species. Apparently the inflorescence is hardly as much capitate as in the next.

* * Calyx phyllis 5 – 6-nervibus, postico etiam integerrimo vel emarginato. Stamina 4: filamenta pl. m. villosa: antheræ omnes biloculares. Folia angusto-linearia seu filiformia,

+ Superiora et floralia 3 – 5-fida, cum ramis minutim scabro- vel subglanduloso-puberula.

CORDYLANTHUS FILIFOLIUS, Nutt., Benth. (*Adenostegia rigida*, Benth. olim.) Folia caulina inferiora integerrima; floralia parce hispida præsertim ad margines, basi subcuneata, segmentis apice pl. m. dilatatis. Flores capitato-conferti. Calycis phylla oblonga obtusa. — I have no Nuttallian specimen of this, but one from Douglas and from other collections. I possess a mere fragment of *C. ramosus*, Nutt., which I suppose to be a slender and somewhat canescent form of the present species.

CORDYLANTHUS WRIGHTII, Gray in Bot. Mex. Bound. p. 120. Folia omnia quæ exstant 3 – 5-partita, filiformia; floralia conformia, nec hispida. Flores pauci ad apice ramorum, pollicares: calycis phylla lanceolata. — Dr. Parry has recently collected this in New Mexico; the flowers evidently purple or purplish.

+ + Folia fere semper etiam floralia integerrima. Flores subpaniculati.

CORDYLANTHUS PILOSUS: elatus (3 – 4-pedalis), pilis mollibus patentibus ut videtur subviscidis cinereus; foliis linearibus, superioribus plerumque apice truncato-emarginatis vel dilatato-trilobulatis; floribus confertis demum furcato-paniculatis; calycis phyllis lanceolato-oblongis. — Dry soil, near San José, Brewer: Oakland hills, Bolander: Upper Sacramento, Dr. Newberry. — Var. BOLANDERI: inferne viscoso-glandulosus, parce seu vix pilosus; floribus laxius paniculatis; foliis

raro truncato-emarginatis, floralibus calycibusque longe laxeque villosis. — Coll. Bolander, probably not far from San Francisco. — Flowers about the size of those of *C. filifolius*. Seeds orthotropous, ovate-oblong, with a hooked point or beak, the testa apparently fleshy and smooth.

CORDYLANTHUS TENUIS: effuse paniculatus, bipedalis, subtilissime puberulus, fere glaber; ramulis filiformibus; foliis angusto- seu filiformi-linearibus, floralibus apice calloso raro bidenticulatis vel emarginatis; floribus mox sparsis; calycis phyllis oblongo-lanceolatis. — Dry sandy soil near Lake Tahoe, Nevada, Brewer, Dr. C. L. Anderson. Near Ostrander's, above Yosemite Valley, Bolander. — Flowers 6 to 8 lines long, purplish and yellowish, scattered on the developed filiform branches. Seeds (immature) resembling those of the foregoing species, semi-ovate with a recurved beak, smooth.

* * * Calyx phyllis utrisque 6-nervibus, postico apice emarginato-bifido. Corolla profundius bilabiata, labio inferiori galea dimidio breviore. Stamina 4: antheræ omnes uniloculares, loculo inferiori aut abortivo aut præsertim in stam. breviorum plane nullo: filamenta villosula. Folia brevia, linearia, conformia, fere semper integerrima.

CORDYLANTHUS LAXIFLORUS, Gray, in Bot. Mex. Bound. l. c. — The flowers are said to be "bright yellow."

§ 2. HEMISTEGIA. Flores ebracteolati, in spicam simplicem quandoque ramosam congesti, singuli in axilla bracteæ amplexantis sessiles, calyce monophyllo (apice bidentato) instructi, sepalo seu phyllo erga bracteam deficiente. Filamenta glabra: antheræ loculi basi tantum ciliolati seu barbulati. — Eglandulosæ, subviscosæ, spithamæi ad pedalem.

* Folia, etiam floralia seu bracteæ, integerrima. Stamina 4, longiorum antheris bilocularibus, breviorum loculo unico parvo (superiore deficiente). Semina rostellata, testa lævi?

CORDYLANTHUS MARITIMUS, Nutt.: subpubescens, pallidus; foliis linearibus seu lineari-lanceolatis glabratis plerisque obtusis patentibus; spica brevi simplici; filamentis valde inæqualibus. — Salt marshes along the coast from San Francisco to San Diego.

CORDYLANTHUS CANESCENS: pube brevi molli cinereus; caule erecto pedali; foliis lanceolato-linearibus acutis suberectis; bracteis lanceolatis; spica seu capitulo paucifloro; floribus purpurascentibus. — Near Carson City, Nevada, Dr. C. L. Anderson. At Lake Washoe in the same district, Dr. Torrey.

** Folia caulina integerrima, floralia seu bracteæ latiora sæpius incisa. Stamina 2. Semina obtusa: testa favoso-reticulata.

CORDYLANTHUS MOLLIS: laxe subhirsuto-villosus; caule ramisque diffusis; foliis caulinis linearibus brevibus; bracteis oblongis inciso 2–3-dentatis vel integris corolla luteo-alba paullo brevioribus; spicis nunc ramosis. — Mare Island, Bay of San Francisco, Charles Wright, in N. Pacif. Expl. Expedition, November, 1855. No one else seems to have met with it. It is a rather coarse, hairy plant, with leaves hardly more than half an inch, the thick and either dense or lax spikes 2 or 3 inches long: bracts sometimes nearly an inch long. Seeds moderately reniform, with a loose and thick cellular-reticulated integument, and no obvious rostellum, but the nucleus is slender-pointed.

ORTHOCARPUS PALLESCENS, Gray in Sill. Jour. 34 (ser. 2.) p. 339. *Euchroma pallescens*, Nutt. herb.; but in the flowers examined the calyx not equally 4-cleft, only 2-cleft, with the segments 2-cleft at the apex or to the middle. To this, however, I would refer a plant of Dr. Lyall's Oregon Boundary collection, received from Kew as "*Castilleia pallida* var.?" No. 291 of Geyer's Coll., mentioned in the enumeration under *C. septentrionalis;* also Dr. Torrey's No. 363, from Donner Lake in the Sierra Nevada, No. 1866 ("tips of bracts and corolla white") and 2838 of Prof. Brewer's collection, from high sierras, and in Klamath Valley, Southern Oregon, by Dr. Cronkhite. It is not easy to decide whether it should be ranked under *Orthocarpus* or *Castilleia.* The root is clearly perennial, as in no other *Orthocarpus*, and the lower lip is not as much triplicate as in some species of *Castilleia;* but in length it very nearly or quite equals the short galea, and its oblong lobes are about as long as the undivided portion. The coat of the seed appears to be cellular-favose, in the manner of *Castilleia*, but at maturity it forms an arilliform covering not much larger than the nucleus, which lies loose within it. The species of *Orthocarpus* most like it is *O. attenuatus*, Gray, which appears to be distinct from *O. hispidus* by its white corolla with less trisaccate lower lip and proportionally longer lobes.

PEDICULARIS ATTOLLENS: *Faucidentes Longirostres;* caulibus erectis gracilibus (semi- ad bipedalibus) apice cum spica elongata angusta primum lanatis; foliis (caulinis superioribus parvis) pinnatipartitis, segmentis linearibus serratis incisisve; calycis dentibus tubo subæquilongis; corollæ rubro-purpureæ galea cassidiformi e calyce breviter exserta labio lato dimidio breviore, rostro abrupto super galeam elevato

vel retrocurvo eaque duplo longiore. — Swamps in the Sierra Nevada, alt. 6 – 11,000 feet, Brewer, Torrey, Bolander, Bridges (193). A well-marked and interesting addition to this section. Flowers about half the size of those of *P. Grœnlandica* or *surrecta;* the linear rostrum barely 3 lines long, thrown abruptly back over the galea and erect or recurved. Capsule ovate, twice the length of the calyx.

PEDICULARIS SEMIBARBATA: *Edentulæ,* subacaulis, fere glabra; foliis pinnatipartitis, segmentis inciso- 1 – 2-pinnatifidis, lobis dentibusque brevibus mucronatis; floribus breviter pedicellatis folioso-bracteatis in spicam subsessilem foliis multum brevioribus congestis; calyce subinæqualiter 5-fido, lobis e basi lata lanceolato-acuminatis; corolla ochroleuca (primum tomentulosa) calyce triplo longiore, galea fere recta obtusa inappendiculata labio erecto apice breviter æqualiter trilobo paullo longiore; filaments 2 longioribus supra medium pilis multiarticulatis villosis, brevioribus fere vel prorsus imberbibus; antheræ loculis basi breviter cuspidatis. — On Mount Dana, alt. 10,000 feet, and Ebbett's Pass, 7 – 8,000 feet, Prof. Brewer. In or near the Yosemite Valley, Bolander, and Mariposa Grove, at and above 5,000 feet. Allied rather to *P. centranthera,* Gray, than to any other; the habit, foliage, and inflorescence similar, but the leaves more divided, only 3 or 4 inches long, and with seldom a trace of callous margins; the flower much smaller, only 7 to 9 lines long; the anthers much shorter and abruptly pointed. Capsule globular, obliquely mucronate, hardly equalling the calyx.

MONARDELLA LEUCOCEPHALA: annua, humilis, cinereo-puberula; foliis oblongis vel sublanceolatis obtusis integerrimis subpetiolatis; involucri bracteis ex toto albo-scariosis nitidis rotundatis 7 – 9-nervatis subapiculatis flores (pro genere parvos) adæquantibus; calycis breviuscule tubulosi dentibus subulatis supra medium albis tubo 15-nervi dimidio brevioribus; corolla parva. — Plains near Merced, in sandy soil, June. Heads numerous, terminating the spreading branches, about two thirds of an inch in diameter. The slender white tips of the calyx-teeth more or less recurved. Corolla apparently white and but little exserted. From the very white and probably enduring involucres of the numerous heads, and the dwarf habit, this marked species may be expected to be a fine ornamental annual in cultivation. — The other annual species are *M. Douglasii,* differing from the others in the widely divergent pinnate veins of the involucral bracts confluent into a strong marginal false vein; *M. candicans,* with very blunt calyx-teeth as well

as bracts, and the only species heretofore recognized as an annual; *M. undulata*, with its larger forms (often confused with the foregoing), the leaves of which are seldom at all undulate, and the bracts are more rigid or foliaceous and less blunt; and the following, which is most like *M. Douglasii* on one hand and *M. undulata* on the other.

MONARDELLA BREWERI: annua, humilis, puberula; foliis oblongis vel spathulatis penninerviis petiolatis; involucri bracteis latissime ovatis subulato-acuminatis plerisque tenuibus 5–7-nervatis vel quintupli-septuplinerviis calyces tubulosos haud superantibus; dentibus calycis obtusiusculis; corolla rosea longius exserta. — Corall Hollow on the dry eastern side of the Californian Coast range south of Monte Diablo, Brewer. Scantily collected, apparently a very distinct species: the specimens little over a span in height. Calyxes merely soft-pubescent; the teeth rather broad, wholly pointless. Nerves of the involucral bracts about 5 from the base, and one or even two pairs from the mid-nerve near the base, converging to the pointed apex. Corolla 3 or 4 lines longer than the calyx. — The two perennial and more or less suffruticose species are found in California, *M. odoratissima* only in the mountains, *M. villosa* in the low country and farther south, and under several forms: among them the var. *leptosiphon*, Torr., passes into var. *glabella* (*M. Sheltonii*, Torr. in Durand, Pl. Pratten.?) which has smaller leaves and heads, no villosity at all, and scarcely any pubescence.

POGOGYNE (HEDEOMOIDES, stam. fert. 2) SERPYLLOIDES (*Hedeoma? serpylloides*, Torr. Bot. Whippl.): pusilla; foliis spathulatis vel obovatis; verticillastris paucifloris sæpe distantibus; dentibus calycis bracteisque nudiusculis parce hirsuto-ciliatis, 2 superioribus paullo longioribus corollam adæquantibus; filamentis 2 sterilibus rudimento antheræ capitatis; stylo superne parcissime hispido; stigmatis lobis inæqualibus. — Martinez, J. M. Bigelow. Oaklands, Marsh's Ranch near Monte Diablo, Arroyo Grande, San Juan near Monterey, &c., Brewer, Bolander. Plant from 2 to 5 inches high, exhales a strong scent of Pennyroyal. Corolla blue or purple-violet, very small. Flowers in some specimens sparse in the manner of *Hedeoma*, in many of the older ones numerous and interrupted-spicate as in *Pogogyne*. Calyx deeply cleft, not bearded in the throat. If it were so, the plant would manifestly belong to *Hedeoma*. But it is a clear congener and very near relative of *Pogoggue zizyphoroides*, Benth. (sparingly collected in flower by Mr. Bolander, with larger and roundish leaves),

which equally has two of the stamens sterile, although their filaments are as long as the truly antheriferous ones. I discern a tendency to the abortion of one pair of anthers and to the inequality of the lobes of the stigma in *P. parviflora* also.

AUDIBERTIA CAPITATA: frutescens, bipedalis; ramis ad apicem usque foliosis glomerulo capitulæformi solitario terminatis; foliis *A. stachyoidei* similibus sed minoribus brevioribus magis petiolatis subtus tantum puberulis, floralibus bracteisque subcoloratis rotundatis vel ovatis obtusis vel interioribus mucrone setiformi instructis flores adæquantibus et involucrantibus. — Summit of Providence Mountain, Mohave Desert, May, 1861, Dr. J. G. Cooper. Flowers purple. Resembles *A. stachyoides* in the rugose leaves, &c., and *A. incana* in the involucrate bracts of the head.

SCUTELLARIA BOLANDERI: *Galericulata*, tenuiter pubescens; caulibus (pedalibus) simplicibus vel inferne ramosis ad summum apicem usque æqualiter crebre foliosis; foliis omnibus conformibus ovato-ellipticis basi levissime cordatis sessilibus subintegerrimis (imisve serrato-crenatis) membranaceis penninerviis; floribus axillaribus oppositis folium subæquantibus; pedicellis calyce brevioribus; corolla pallide cærulea seu albida (fere pollicari). — Clark's Meadows, Mariposa Co., in patches, Bolander. Leaves an inch or less in length, thin, rounded at summit, in their venation intermediate between *S. galericulata* and *S. nervosa*.

STACHYS ALBENS: mollissime albo-tomentosa, nec unquam hirsuta; caule erecto valido (1-5-pedali); foliis cordato-ovatis vel subcordato-oblongis crenatis, inferioribus petiolatis, superioribus plerisque subsessilibus, floralibus calyces adæquantibus; verticillastris plurifloris approximatis sæpius in spicam densam interruptam confertis; bracteis obsoletis; calycibus subsessilibus villosissimis obconico-campanulatis, dentibus deltoideis pungenti-cuspidatis; corolla alba calyce duplo longiori, tubo calycem paullulo superante, galea superne villoso-barbata. — California: Fort Tejon, Mr. Xantus (No. 80, taken for a var. of *S. pycnantha*): Ojai, Dr. Peckham; Pechecos Pass, near water-courses, Brewer, Bolander; Yosemite Valley, a dwarf exceedingly woolly form, Bolander. Stem in the taller specimens "often an inch square at base, above much branched." Corolla white, with a few purple or rose-colored dots near the base of the lower lip.

TRICHOSTEMA LAXUM: *Orthopodium*, tenuiter pilosum vel pubescens; caule laxe ramoso; foliis penninerviis lanceolatis sæpiusve ob-

longo-lanceolatis utrinque attenuatis vel acutis longiuscule petiolatis; cymis axillaribus pedunculatis demum furcatis, ramis elongandis secundo-plurifloris; pedicellis calyce vix brevioribus; lobis calycis æqualibus subovatis tubo æquilongis; corollæ tubo tenui exserto. — Near Little Geysers, Napa County, Brewer. Pope's Valley, Bolander. I have also specimens raised from Californian seed, of unknown source, in 1866, by Mr. Elihu Hall. Most related to *T. lanceolatum*, Benth.; but with much more evolute cymes of smaller flowers; and the distant, petioled, feather-veined leaves are much more like those of *T. dichotomum*.

Lycium Cooperi: ramis validis; foliis viscoso-puberulis spathulatis retusis rigidulis pauci-venosis (cum petiolo 6 – 9 lin. longis); floribus 5-meris; calyce cylindraceo-campanulato basi abrupto quasi truncato cum pedicello æquilongo viscoso-pubescente, lobis oblongis obtusis tubo suo æquilongis corolla infundibuliformi (semipollicari) dimidio brevioribus; filamentis basi pilosis; antheris ovalibus mucrone minimo apiculatis. — East slope of Providence Mountain, in the Mohave District, California, Dr. J. G. Cooper. Stems "2 feet high"; spines very short. Pedicels 3 or 4 lines long. Lobes of the corolla ovate, very much shorter than the tube. The species ranks between *L. pallidum* and *L. puberulum*.

Lycium Andersonii: glaberrimum; foliis parvis ($1\frac{1}{2}$ – 3 lin. longis) spathulatis; calyce brevi-campanulato margine repando-quadridentato seu denticulato pedicello (sesquilineam longo) sæpius breviore; corolla angusto-tubulosa fere semipollicari fauce subampliata, lobis 4 latissimis tubo multoties brevioribus antheras adæquantibus; filamentis basi glanduloso-pilosis. — S. E. part of State of Nevada, Dr. C. L. Anderson. Allied to the *L. Torreyi* and *L. Fremonti* of my revision of the genus.

Menodora (Bolivaria) spinescens: minutissime puberula, ramosissima, ramis ramulisque divaricatis lignosis spinescentibus; foliis nunc ad squamas exiguas reductis nunc parvis (lin. 1 – 3 longis) spathulatis, omnibus alternis; calycis 5- (raro 6-) partiti segmentis lineari-subulatis corollæ tubum infundibuliformem (lobis obovatis suis paullo longiorem) subæquantibus; filamentis antheris oblongis subexsertis brevioribus; stigmate minuto emarginato; ovarii loculis biovulatis. — Cañons and hillsides, southeastern part of the State of Nevada, fl. March, Dr. C. L. Anderson. This is an interesting addition to the genus, being apparently of the same group with the original South

American species of *Bolivaria;* but the filaments are short and adnate almost up to the throat of the corolla. The latter is about 3 lines long, and apparently yellowish tinged with pink. Stems one or two feet high.

MONOLEPIS SPATHULATA: foliis integerrimis spathulatis; glomerulis globosis; utriculo pyriformi crebre papuloso-scabro; semine lævissimo turgido immarginato. — Sierra Nevada, at Mono Pass, in loose soil, Bolander. The seed is several times smaller than that of *M. chenopodioides.*

ERIOGONUM SPERGULINUM: *E. pharneceoidei* Torr. simillimum; pube foliorum pilosa nunquam tomentosa; inflorescentia floribunda magis effusa; involucris multo minoribus glabris quadrifidis unifloris; perigonii laciniis exterioribus oblongis. — Dry sandy soil, banks of Big Creek below the Mariposa Big-tree Grove, Bolander. Also collected by the late Mr. Bridges.

HABENARIA THURBERI: *H. dilatatæ* et *hyperboreæ* peraffinis; spica angustissima; sepalo postico rotundo-ovato; labello angusto lineari e basi haud dilatata deflexo sepalis duplo longiore calcare filiformi ovarium adæquante vel superante paullo breviore; glandulis stigmatis ovalibus. — Arizona, Thurber (925), C. Wright (1,900), referred by Dr. Torrey in Bot. Mex. Bound., to *Platanthera leucostachys,* Lindl., which I take to be a form of *P. dilatata.* A variety of this with more slender and loose spike of apparently more greenish flowers is 6251 of Bolander's collection, from near the Mariposa Grove and Yosemite Valley.

CYPRIPEDIUM CALIFORNICUM: puberulum; caule folioso (ad sesquipedalem); foliis inferioribus late ovalibus ovatisque, superioribus lanceolatis; floribus 4 – 6 dissitis folio brevioribus ochroleucis, sepalis (postico e duobus conflato integerrimo rariusve apice bilobo) latissime ovalibus petala lato-linearia obtusa plana labellumque obovato-globosum adæquantibus; stamine sterili fornicato. — Swamps on Red Mountains, Mendocino Co., Bolander. Flowers most like, and rather smaller than, those of *C. passerinum.*

BRODIÆA COCCINEA (*Brevoortia Ida-Maia,* A. Wood in Proceed. Acad. Philad. June, 1867): scapo elato; umbella 5 – 12-floro; perigonio infundibulari-cylindraceo ventricoso pedicello tenui duplo longiore coccineo, lobis viridulis mox flavidis ovatis recurvis tubo multo brevioribus squamis faucialibus latissimis erosulis (antheras 3 sessiles subæquantibus) subduplo longioribus; stigmate trifido, lobis emarginatis.

— Shasta Co. California, A. Wood, 1866. On the divide between Russian and Eel Rivers and northward, Bolander, 1867. Professor Wood has naturally characterized this very striking and handsome plant as a new genus, — to which, indeed, it has as good a claim as *Dichelostemma* or perhaps even *Stropholirion*. But, however *Brodiæa* be limited, it cannot well fail to include this species, which has wholly the structure of the typical *B. grandiflora*, only that the tube of the flower is proportionally longer, the scales answering to the other set of stamens much broader, and the color peculiar in the genus, although not unlike that of *Stropholirion*. In referring it to *Brodiæa* we may venture to discard the objectionable double-headed specific name, given by the stage-driver, Mr. Burke (who showed the plant to Professor Wood), "in affection for his little daughter."

ALLIUM OCCIDENTALE = *A. reticulatum*, Hook. Fl. Bor.-Am. pro parte, & Pl. Hartw. No. 1995; ab *A. reticutato* Fras. differt bulbo nunquam vaginis reticulatis tecto, segmentis perigonii latioribus, cristis seu dentibus ovarii brevissimis, etc. — Apparently common in California.

ALOE YUCCÆFOLIA (*Yucca? parviflora*, Torr. Bot. Mex. Bound. p. 221): acaulis; foliis elongatis angusto-linearibus recurvo-patentibus rigidis canaliculatis tenuiter striatis lævibus margine *Yuccæ* modo filiferis; scapo 2 - 4-pedali scarioso-bracteato; racemo vel panicula elongata; floribus fasiculatis; perianthio æquali cylindrico dilute rubro; filamentis rectis subexsertis; stylo demum longius exserto; capsula ovata primum carnosa demum 6-valvi. — S. W. Texas, C. Wright (685, with flowers and mature fruit), 1908 (with unripe fruit, &c.), J. M. Bigelow, ex Torr. Flowers an inch long. Style at length with the exserted portion incurved or geniculate in the flowers developed in Cambridge Botanic Garden. Fruit and seeds, no less than the leaves, resembling those of *Yucca*.

HESPEROCALLIS, Nov. Gen. *Liliacearum*.

Perigonium corollinum, infundibuliforme, marcescendo-persistens; limbo regulari 6-partito tubo longiore, segmentis conformibus oblongo-spathulatis basi attenuatis medio 5 - 7-nervatis. Stamina 6, fauci inserta: filamenta filiformia, recta: antheræ lineares, supra basim introrsum affixæ. Ovarium triloculare, loculis multiovulatis: stylus filiformis: stigma depresso-capitatum. Capsula subglobosa, loculicida, polysperma. Semina compressa, exalata, testa ut videtur subcarnosa molli. — Herba

glaberrima; caule foliato bipedali e "bulbo eduli" (an cormo?); foliis linearibus elongatis crassis planis margine insigniter undulatis; racemo paucifloro; pedicellis brevibus bractea scariosa suffultis cum flore articulatis.

HESPEROCALLIS UNDULATA. — Desert plains at Jessup Rapids, Arizona or New Mexico; "the bulb eaten by Indians," Prof. Newberry. Gravelly plains at Fort Mohave, Dr. J. G. Cooper. Flower 2 inches long. Capsule half an inch or more in length, apparently thickish. The seeds seen not fully ripe, but evidently with a soft or rather fleshy-coriaceous testa. The plant appears to be most related to *Hemerocallis*, and the generic name is intended to suggest that affinity, along with the far western, instead of eastern habitat. The "bulb," whatever it may prove to be, did not accompany the specimens of either collector.

NARTHECIUM OSSIFRAGRUM, Linn., var. OCCIDENTALE. Swamps at Red Mountains, Humboldt Co., Bolander. An interesting discovery in a geographical aspect, this, with the recent detection of a new species (*N. Asiaticum*, Maxim.) in Japan, greatly extending the range of the genus. While the Japanese species, by its narrow sepals, shortish anthers, and shorter more crisped wool of the filaments, most approaches *N. Americanum*, the present plant, with loose raceme and broadish leaves, closely resembles the W. European plant; from which it seems to differ only in the rather broader, and perhaps larger, divisions of the perianth. The position of the bractlet varies, as it also does in the other forms.

VERATRUM FIMBRIATUM: floribus fere pollicem diametro insigne, perianthii phyllis obovato-cuneatis supra unguem brevem latum composite longeque fimbriatis; foliis *V. viridi* similibus, majoribus sesquipedalibus. — On the undulating plains west of the Redwoods in Mendocino County, Sept., 1865, Bolander. The flowers of this most remarkable species are apparently greenish-white, with two darker spots at the base of the lamina.

HEMICARPHA OCCIDENTALIS: pallida; capitulis solitariis binisve ovatis vel subglobosis hystricinis; squamis e basi ovata scariosa costa valida percursa in acumen patulum rigidum æquilongum productis achenium cum squamula interna ovata eroso-truncata vel excisa ter longioribus. — Common in Yosemite Valley, Bolander. This apparently grows, just as does *H. subsquarrosa* in the Eastern United States, in company with *Cyperus inflexus*. Heads much thicker than those

of the original species, owing to the long and squarrose points of the scales, pale greenish.

ELEOCHARIS BOLANDERI: *E. uniglumi* similis, absque rhizomatibus repentibus modo *E. multicaulis;* caule tenuiori striato-angulato; stigmatibus 3; achenio albido lævi pyriformi angulis 3 acutis costato, apice quasi truncato tuberculo latissimo depresso fere disciformi prorsus confluente coronato; setis tenuibus 3–4 retrorsum scabris achenio 2–4-plo brevioribus. — Mariposa County, on banks of stream near Clark's, Bolander. Fruit mostly immature in the specimens: scales of the spike dark brown.

SCIRPUS (ISOLEPIS) PYGMÆUS, — preserving the earliest specific name for this common Californian as well as S. American and Australian plant, which was inadvertently named "*Isolepis carinata*" in an early distribution of some of Mr. Bolander's plants, No. 57. It is *Isolepis leptocaulis,* Torr. in Bot. Whippl. p. (153) 97. It appears to grow in company with, but is quite distinct from,

SCIRPUS (ISOLEPIS) CARINATUS, the *Isolepis carinata,* Hook. & Arn., which is near *I. cartilaginea,* R. Br.

SCIRPUS (TRICHOPHORUM) CRINIGER: caulibus e rhizomatibus dense cæspitosis strictis (bipedalibus) triquetris, angulis sub apice scabris; foliis planis, radicalibus angusto-linearibus elongatis, caulinis lato-linearibus brevibus sæpius vagina brevioribus; spicis paucis oblongis in capitulum unicum rariusve geminatum arcte congestis; involucro monophyllo subulato vel subnullo; squamis ovatis tenuibus trinervibus fulvis muticis (infima majore bracteante acuminata vel cuspidata) filamentis 3 et perigynii setis 6 tenuibus antrorsum scabris dimidio brevioribus; achenio obovato-triquetro cuspide brevi apiculato. — In bogs, on Red Mountain, Humboldt Co., Bolander. An interesting plant, with nearly the habit and inflorescence of *Eriophorum Virginicum,* but usually with only one glomerule, composed of 5 to 9 very crowded spikes, and the involucre small and simple or none, and comose with fulvous, but not very tortuous, long bristles and persistent filaments. The number and the serrulation of these bristles refer the species to *Trichophorum;* rather than to *Eriophorum.* The rather broad cauline leaves are from 3 to only 1½ inches long, acute, smooth, or the edges minutely scabrous.

The *Carices* of these collections having been referred to Mr. Olney, he has obligingly furnished characters of the following proposed new species, along with two or three of Eastern habitat.

Carices Novæ a STEPHEN T. OLNEY, A. M., *descriptæ*, 1868.

CAREX BOLANDERI, Olney, n. sp.: spica elliptica pallida albo-viridi demum lutescente e spiculis 5 – 6 (rarius 4 – 10) parvis ellipticis sessilibus plerumque androgynis basi masculis, superioribus contiguis, infima vel binis inferioribus remotis bracteatis; stigmatibus 2; perigyniis ovalibus vel ellipticis acuminato-rostratis bifidis plano-convexis margine acutis serratis nervatis basi spongiosis squama ovata hispida aristata albo-hyalina nervo viridi longioribus; achenio orbiculato vel ovato punctulato stramineo, basi styli plus minus bulbosa. — California, Yosemite Valley and Mariposa Big-tree Grove, Brewer, 1665; Dr. Wm. Hillebrand, 2313; Bolander, 6201, 6209. This is closely allied to *C. Deweyana*, Schweinitz, from which it differs in its less acutely angled culm, more approximate and many- (10 – 30-) flowered spikes, shorter bracts, the oval or elliptical and nerved perigynia, and long-awned hispid scales.

CAREX ATHROSTACHYA, Olney, n. sp.: spica globosa capitata involucrata straminea e spiculis 8 – 20 basi masculis dense congestis vel infima subinde discreta; bracteis 3 – 5 inferioribus foliaceis spicam longe superantibus, basi expansa hyalino-marginata; stigmatibus 2; perigyniis ovato-lanceolatis in rostrum elongatum attenuatis basi spongiosis marginibus alatis serratis alte bifidis leviter nervatis; squama ovato-lanceolata acuminata membranacea; achenio orbiculato plano-convexo lucido nec punctulato. — California, Yosemite Valley, June 17, Brewer, 1650; Hillebrand, 2311, a var.; Bolander, 6213; Silver Valley, alt. 7,400 feet, Brewer, a variety. — Cæspitose: culms acutely triangular, leafy, 1½ – 2 feet high; leaves narrow, shorter than the culm. Allied to *C. sycnocephala*, Carey; from which it differs in its shorter leaves, heads with more spikelets, bracts expanding at the base into a membranaceous border, and broader and more ovate irregularly-nerved perigynia.

CAREX STRAMINEA, Schk., var. CONGESTA, Boott, in litt. Apr. 1863: spica congesta, squamis castaneis. — California, Brewer, on Mount Shasta, 1375, 1397, 1398, 1399.

CAREX SILICEA, Olney: "spiculis 2 – 10 pallidis demum stramineis plerumque alternatim remotiusculis omnibus (terminali sæpe magis conspicue) basi conico-masculis nudis, infima subinde composita; perigyniis ovalibus vel orbiculatis e basi late alatis brevi plerumque sensim rostratis compressis appressis plus minus plurinerviis squama lanceolata acuminata acuta latioribus paulo longioribus vel æquantibus."

C. straminea, var. *moniliformis*, Tuckerm. Enum. p. 17. *C. straminea*, var. Sartwell, Exsicc. No. 49. *C. fœnea*, Boott, Ill. Car. 3, p. 118, tab. 377. *C. fœnea*, var.? *sabulonum*, Gray, Man. ed. 5. *C. adusta*, Carey in Gray, Man. ed. 1. non. Boott. *C. festucacea*, Sartwell, Exsicc. No. 44, ex parte. — Maine, on the coast, rocks and beaches, Tuckerman. New Hampshire, Isle of Shoals, Canby. Rhode Island, on rocks and beaches, Narragansett Bay. Massachusetts, Ipswich, in sand, Oakes. New York, Sartwell. Cape Henlopen, Delaware, Canby. June, July. — The different color, the alternate spikelets, nutant spikes (in this resembling *C. straminea*, var. *aperta*, Boott), and involute leaves, surely separate this from *C. fœnea*. The fruit matures early; that of *C. fœnea* ripens a month or more later.

Carex senta, Boott, n. sp.: "Mr. Brewer has recently found in California specimens which, in habit, closely resemble *C. angustata*, Boott, but differs in the perigynum being conspicuously toothed at the margin, and the vagina of the leaves externally scabrous, and in the larger size of the perigynum." Boott, Ill. Car. 4, p. 174. It is Brewer's No. 350, which was collected in a cañon of the Santa Inez Mountains, California.

Carex bifida, Boott, n. sp. "With the habit of *C. Buxbaumii Wahl.* differs in the bifid orifice of the perigynum, which is not granulated; the leaves are broader, and scales shorter." Boott, MSS. April, 1863. It is Brewer's No. 574, of Salinos Valley, south of Monterey, and Bolander's 6476 from Red Mountain, Humboldt County.

Carex gynodynama, Olney, n. sp.: spicis 4 – 5 cylindricis erectis ferrugineis, terminali masculi apice fœminea, reliquis fœmineis, suprema masculam longe superante, infima remota longe vaginata pedunculata; bracteis involutis ciliatis, infima culmo subæquali vel breviore; stigmatibus 3; perigyniis ellipticis rostratis bifidis olivaceis basi leviter nervatis (apice purpureo pilis longis albis vestito, basi glabra) squama ovata membranacea ciliata mucronata vel acuta castanea medio pallida latioribus et brevioribus; achenio obovato triquetro olivaceo. — California, near Mendocino City, Bolander, 4700. Cæspitose: culms 10 – 18 inches high, leafy, and with long sheaths: leaves much shorter than the culm, flat, ciliate. This species probably belongs to the *Ferrugineæ* group.

Carex Whitneyi, Olney, n. sp.: spicis 4 (rarius 3 – 5) erectis albo-viridibus, terminali masculi (rarius 2) oblonga vel cylindrica rarius pedunculato, reliquis fœmineis evaginatis sublaxifloris oblongis

contiguis, infima pedunculata (rarius remota longissime exserte pedunculata); bracteis culmo brevioribus vel infima paullo longiore; stigmatibus 3; perigyniis ovalibus acute triquetris rostratis nervatis glabris (ore emarginato antice altius secto); squama ovata cuspidata membranacea apice ciliata medio viridi trinervi longioribus; achenio ovato acute triquetro. — California, Yosemite Valley, Brewer, 1639, Bolander, 6198, Hillebrand, 2305, 2308, 2314; Mount Dana, 12,000 feet, Bolander, 5086; Soda Springs, 9,000 feet, Brewer, 1778. Whole plant except perigynia and scales whitish or glaucous-pubescent; the sheaths densely so. Culm 1–3 feet high, erect, acutely triangular. Leaves shorter than the culm, 3–4 lines wide. This and *C. pubescens*, Muhl., *C. dasycarpa*, Muhl., *C. tenax*, Chapman, *C. triquetra*, Boott, and *C. Halleriana*, Asso, form a very natural group, which Carey has indicated in Herb. Gray as *Triquetræ*. Dedicated to the Director of the Survey under which the specimens were collected.

Carex luzulina, Olney, n. sp.: spicis 4–5 rarius 6 fusco-ferrugineis; superioribus contiguis brevi-oblongis densifloris sessilibus, terminali mascula, fœmineis inferioribus bracteatis longe vaginatis, infima interdum longe pedunculata remota; stigmatibus 3; perigyniis oblongo-ovalibus vel ovatis rostratis bifidis obsolete nervatis glabris rostro serrato squama ovata obtusa castanea nervo pallido-viridi ciliata brevioribus; achenio obovato. — California, Mendocino City, Bolander, 4740. Culms 7–12 inches high, leafy at base: leaves short, 2–4 inches long, 3 lines wide, smooth and flat; the lower recurved. Allied to *C. præcox*, Jacq.

Carex glaucodea, Tuckerman, MSS. "Spicis 4–5 cylindricis, terminali mascula subsessili clavata, reliquis fœmineis folioso-bracteatis multifloris, superioribus approximatis exserte (inferiori remota longe) pedunculatis pallide viridibus; stigmatibus 3 brevibus; stylo æquali; perigyniis ovoideis turgidis obtusis ore sub-integro multinerviis glauco-viridibus squama late ovata breviter cuspidata albida medio viridi trinervi vix dein duplo longioribus; achenio obovato triquetro." — Moist trap rocks, summit of Mount Holyoke and Mount Tom, Tuckerman; New Jersey, C. F. Austin; woods near Philadelphia, C. E. Smith; Bethlehem, Penn., Prof. Porter; Lancaster Co., Penn., L. Fiot; Delaware, near Wilmington, Canby. — Plant scarcely erect; culms 6–12 inches high, smooth and glaucescent in all parts; leaves wider than in *C. grisea*, 2½–4 lines wide, shorter than the culm. From *C. grisea* it differs in its wider leaves, cylindrical densely and many-flowered spikes,

in the glumes, fewer-nerved perigynia, smaller *ovoid* always pointless perigynia. From *C. flaccosperma* it differs in its smaller *ovoid* always pointless perigynia. *C. flaccosperma* and *C. grisea* agree in their oblong and pointed or almost rostrate fruit. The closest affinity of *C. glaucodea* is probably with *C. granularis.*

Carex Sartwelliana, Olney, n. sp.: spica subelongata castanea e spiculis 5 – 6 (rarius 4 – 8) cylindricis densifloris erectis, terminali mascula, reliquis fœmineis castaneis sub-squarrosis sessilibus approximatis; bracteis evaginatis, inferioribus culmum superantibus vel infima subinde sterili remota vaginata; stigmatibus 3; perigyniis castaneis triquetris rostratis (ore integro oblique secto) undique pubescentibus squama ciliata et pubescente lanceolata cuspidata vel ovata castanea nervo viridi latioribus et longioribus; achenio perigynio conformi triquetro angulis costatis. — California, Yosemite Valley, alt. 6,000 feet, Brewer, 1,636; Bolander, 6,221. Culms 2 – 3 feet high, glaucous, and whole plant pubescent, the sheaths of the leaves densely so. Allied to *C. scabrata*, Schw. and *C. amplifolia*, Boott; the three species forming a natural group. From the latter it may be distinguished by its shorter fertile spikes and densely tomentose or pubescent perigynia: from the former by the shape of its almost nerveless perigynia. — The *C. Sartwellii* of Dewey being only *C. disticha*, the present well-marked species is now dedicated to the memory of the late Dr. Henry P. Sartwell, of Penn Yan, New York, who has done so very much for the Caricology of the United States.

Carex cinnamomea, Olney, n. sp.: spicis 3 – 5 erectis, terminali mascula fusiformi cinnamomea longe pedunculata, reliquis fœmineis cylindraceis densifloris, superioribus approximatis, inferioribus longe exserte pedunculatis basi attenuatis laxifloris, infima remota; bracteis vaginatis culmo longioribus vel brevioribus; stigmatibus 3; perigyniis ellipticis triquetris viridibus rostellatis glabris nervatis (ore bidentato intus ciliato) squama ovata vel obtusa membranacea spice ciliata cinnamomea medio viridi latioribus longioribus; achenio triquetro obovato. — Swamps of Red Mountain, Humboldt Co., California, Bolander, 6477. Culms 1½ – 2 feet long, erect, with short and narrow scabrous leaves, the rudimentary ones dark purple. The species belongs to the *Debilis* group, agreeing with *C. Sullivantii*, Boott, in having erect firtile spikes, and with *C. glabra*, Boott, in its sharply two-toothed, prominently nerved, and smooth perigynia.

S. T. O.

*** *Curæ Posteriores*, 1868.

PARRYELLA, Torr. & Gray, Nov. Gen. *Leguminosearum.*

Calyx obconicus, 5-dentatus, dentibus brevibus æqualibus. Petala nulla. Stamina 10: filamenta ima basi calycis inserta, libera: antheræ uniformes. Ovarium biovulatum; stylus crassiusculus e calyce leviter exsertus, apice uncinatus; stigma glandulæforme laterale *Eysenhardtiæ.* Legumen indehiscens, oblique obovatum, grosse glandulosum, basi attenuata calyce persistente stipatum, semine solitario ovali repletum. Cotyledones oblongæ, foliaceæ; radicula inflexa. — Frutex Novo-Mexicanus, parvus, ramosissimus, fere glaber; ramis tenuibus scopariis foliisque parce glanduloso-punctatis; foliolis plurijugis cum impari filiformibus canaliculatis petiolulatis; stipulis stipellisque nullis vel ad glandulas parvas reductis; floribus pusillis in spicis terminalibus.

PARYELLA FILIFOLIA. — New Mexico, along the Rio Grande below Albuquerque, Dr. C. C. Parry. Flowers barely a line and a half in length; the turgid *Psoralea*-like legume 3 or 4 lines long, not wrinkled, smooth, but beset with large yellowish glands in the manner of *Dalea*, its base only covered with the turbinate persistent calyx. Filaments and pubescent style barely exserted. Although the stamens are distinct to the base, yet this is evidently a true Psoraleaceous plant, and closely related to *Eysenhardtia;* but not to be confounded either with that genus or *Amorpha.* The preoccupation of the name *Parrya* in behalf of the arctic navigator need not frustrate the natural desire that our Dr. Parry's name should be commemorated in a generic type of his own discovery, inhabiting some of the wide western regions which he has so faithfully explored during the past twenty years.

DALEA PARRYI, Torr. & Gray: suffruticosa, tenuiter puberula; ramis gracilibus diffusis mox glabris; foliolis 7 – 11-jugis obcordatis vel obovatis emarginatis ($1\frac{1}{2}$ – 2 lin. longis) parce grossius glanduloso-punctatis; spicis longe pedunculatis elongatis multifloris demum laxis; calyce sericeo-canescente ad medium usque 5-fido, lobis 4 oblongis obtusis, infimo lanceolato acuto paullo longiore; corolla saturate violaceo; legumine glabello. *D. divaricata* var. *cinerea*, supra, p. 335. — Gravelly hills near Fort Mohave, Dr. J. G. Cooper, and lower down on the Colorado, near the mouth of Williams River, Dr. C. C. Parry. The specimens of the latter are smoother as to the foliage, and therefore agreeing in this respect with Bentham's *D. divaricata* of Lower California; but the silky-canescent calyx (fully a line and a

half long) and the apparently larger corolla also (fully 4 lines long when well developed, and richly colored) lead to the conclusion that this is a distinct species.

ASTRAGALUS ARIZONICUS: (*Micranthi?*) procumbens, suffrutescens, pube strigulosa canescens; stipulis parvulis petioli basi adnatis; foliolis 5 – 7-jugis linearibus acutis; spicis in pedunculo folium superante sparse plurifloris; floribus subsessilibus; calycis dentibus subulatis tubo campanulato æquilongis; corolla albida sursum purpurea, carina apice inflexo producto obtuso; leguminibus immaturis oblongo-linearibus estipitatis cano-puberulis pl. m. obcompressis septo completo bilocellatis pleiospermis. — Arizona, near Camp Grant, April, Dr. Edward Palmer. Probably same as the plant from Tubac, Dr. Parry, and Los Nogales, Capt. E. K. Smith, mentioned at the end of my revision of the genus (p. 234). But Dr. Palmer's specimens are less white, the calyx with some dark hairs intermixed, and the flowers smaller; those in Capt. Smith's specimens are half an inch long, in both too large to be properly ranked among *Micranthi*. The inflexed and almost beak-like but obtuse summit of the keel is nearly as in *A. Sonoræ* and *A. humistratus*.

ASTRAGALUS (PHACA) PALMERI: cinereo-puberulus, glabratus; caule ultrapedali; stipulis brevissimis; foliolis 8 – 13-jugis oblongis; spicis in pedunculo folium superante strictis laxius multifloris; bracteis subulatis pedicello brevissimo æqualibus; calycis dentibus subulatis tubo campanulato fere æquilongis corolla purpureo-cærulea dimidio brevioribus; leguminibus arrectis estipitatis puberulis plano-compressis semi-ovatis, suturis acutis haud introflexis, ventrali medio 5 – 7-sperma. — Camp Grant, in Southern Arizona, Dr. Edward Palmer, comm. Engelmann. Base of the stem not seen. Leaflets 6 – 9 lines long. Spike 4 – 5 inches, flowers 3 lines, legumes half an inch in length. From the fruit it should be placed with the *Homalobi*, but the habit is rather different, and the pod very broad.

ASTRAGALUS HORNII (PHACA, *Inflati*): caule erecto (ut videtur bipedali) glabro; stipulis minimis subulatis discretis mox reflexis; foliolis multijugis oblongo-linearibus adpresse pilosulis; pedunculis folia æquantibus capitato-plurifloris; floribus fere sessilibus; calyce corolla flavida rectiuscula dimidio brevioribus, dentibus subulatis tubum brevi-campanulatum subæquantibus; leguminibus (pro sectione parvulis) arcte capitatis estipitatis brevi-ovatis acuminatis pilosis inflatis 10 – 15-spermis. — Near Fort Tejon, or in Owen's Valley, Tulare Co.,

in S. E. California, Dr. G. H. Horn, 1863.—This belongs to the subdivision which comprises *A. macrodon* (of which the fruit is still unknown) and *A. Douglasii.* It is remarkable for the capitate flowers, rather few ovules, and very pointed, ovate-acuminate, crowded pods, which are barely two thirds of an inch in length.

LATHYRUS SULPHUREUS, W. H. Brewer (*L. ochroleucus?* Torr. in Bot. Whippl., p. 21, non Hook.): caulibus acute angulatis; foliolis 8–12 oblongis vel ovato- seu oblongo-lanceolatis subcoriaceis rigidis (lin. 6–18 longis) reticulatis; stipulis semisaggitatis sensim acuminatis vel acutissimis; pedunculis folium adæquantibus plurifloris; floribus brevibus (semipollicaribus); calycis dentibus valde inæqualibus; corolla sulphurea obtusissima, vexillo alas carinamque latam semirotundatam tantum æquantibus.—In woods, &c., along the foot-hills of the Sierra Nevada, from several collectors. Variously confused with *L. ochroleucus, venosus,* &c. Apparently the color of the flowers alone has caused it to be referred to the former, and these are not "yellowish white," but truly "sulphur-yellow." The limb of the keel is almost as wide as long.

CASSIA COVESII: pube brevi sericea subnitente undique incana; caule 1–2-pedali e radice perenni; stipulis setaceis; foliolis 2–3-jugis ellipticis basi inæqualibus mucrone cuspidatis, glandula cum stipite tomentoso setacea inter omnia paria; racemis corymbosis plurifloris; legumine pollicari brevi-oblongo fere recto tumido canescente pedicello paullo longiore seminibus horizontalibus farcto, valvis submarginatis.—Camp Grant, and south of Prescott, Arizona, Dr. Elliott Coues (to whom the species is dedicated) and Dr. Edward Palmer. "Root used by the Indians as a cathartic. Flowers bright orange-yellow." In aspect, foliage, and flowers very like *C. Lindheimeriana,* except that there are never more than 3 pairs of leaflets; and the legume is very different, resembling that of *C. bauhinioides* and *C. Rœmeriana,* but more turgid; the oval seeds apparently horizontal.

POTENTILLA (COMARUM) DEPAUPERATA, Engelm. MSS.: pilosula, erecta; foliis pinnatisectis; foliolis lineari-lanceolatis, panicula pluriflora; sepalis purpurascentibus e basi lata attenuato-subulatis accessoria angusto-subulata bis excedentibus; petalis parvis linearibus atropurpureis; staminibus 5; carpellis 2 in receptaculo longe villoso.—Williams Mountain, Western New Mexico, A. L. Anderson. "A remarkable species, connecting, as it does, *Ivesia* with the section *Comarum.*" G. Engelmann.

Œnothera Whitneyi, p. 340, is evidently *Godetia grandiflora*, Lindl. Bot. Reg. 28, t. 61; but it may retain this name in *Œnothera* on account of the old *Œ. grandiflora*, Ait.

Lewisia brachycalyx, Engelm. MSS.: foliis spathulatis vel sublinearibus; scapo haud articulato nudo (ima basi tantum bibracteolato); calyce herbaceo decussatim 4-sepalo (sepalis ovatis) petalis 7 – 9 cuneato-obovatis 2 – 3-plo brevioribus; staminibus 10 – 15; stigmatibus 5 – 7 stylo breviore. — W. New Mexico, Dr. Newberry. Fort Whipple, Arizona, Doctors Coues and Palmer; and Utah, Dr. Brewer, in herb. Engelmann. Plant with the habit of *Talinum pygmæum* and *Calandrinia acaulis*, but necessarily associated with Lewisia on account of the number of the sepals and the dehiscence of the capsule (circumsissile at base); yet too closely related to *Calandrinia*. Flowers less than an inch long, "fragrant; petals white with purple veins." Cotyledons incumbent; those of *L. rediviva* are figured in Bot. Beechey, probably incorrectly, as accumbent. G. Englemann.

Leucothoe Davisiæ, Torr. MSS.: *Euleucothoe;* foliis elliptico-oblongis utrinque obtusis tenuissime serrulatis breviter petiolatis; racemis terminalibus laxifloris folia longe superantibus; sepalis ovato-lanceolatis cum bracteolis bracteisque subscarioso-albidis; antheræ loculis bimucronatis. — Nevada Co., near Eureka, California, Miss N. J. Davis; one out of a fine and beautifully prepared collection of plants recently made by her in that district. In mode of growth, inflorescence, and flowers, this interesting new Western representative of the genus accords with Leucothoe proper (as characterized in Gray's Manual), except that the racemes are terminal and much surpassing the leaves. These are one and a half or two inches long.

Phacelia (Eutoca) hydrophylloides, Torr. MSS.: humilis, e rhizomate ramoso repente multicaulis; foliis ovatis subrhombeis oblongisve obtusis inciso-paucidentatis lobatisve nunc lobis infimis fere discretis lyratis utrinque nitenti-sericeis, petiolo laminam æquante caule et inflorescentia hispidulis; cyma terminali parva conferta; corolla cærulea campanulata calyce paullo longiore, appendicibus latissimis maximis; genitalibus exsertis; placentis 6 – 8 - ovulatis; capsula oblonga acuta calycem adæquante. — Ebbett's Pass, and near Lake Tenaya, 8 – 9,000 feet, Brewer. Open woods along the trail of the Yosemite, from 8,000 down to 5,000 feet, Bolander. Stems 3 – 6 inches high.

DRAPERIA, Torr. Nov. Gen. *Hydrophyllearum.*

Calyx e sepalis 5 angustissimis. Corolla tubuloso-infundibuliformis, limbo 5-lobo. Stamina 5, inæquilonga; filamentis inappendiculatis corollæ tubo inæqualiter adnatis. Stylus filiformis, apice bifidus; stigmata capitellata. Ovarium biloculare: ovula in loculis gemina, anatropa, ex apice fere placentæ nerviformis pendula. Capsula globosa, subdidyma, membranacea, loculicida, valvis a dissepimento utrinque dispermo solutis. Semina loculos replentia, facie concava medio carinata. — Herba multicaulis, humilis, sericeo-pilosa; caulibus diffusis basi lignescentibus; foliis oppositis ovatis penniveniis integerrimis longius petiolatis; cymis scorpioideis nudis tenuiter pedunculatis; floribus ebracteatis confertis pallide purpureis. Genus inter *Namam* et *Phaceliam* quasi medium insigne.

Draperia systyla, Torr. *Nama systyla,* Gray in Proceed. Amer. Acad. 6, p. 37. California, Lobb.; in the Yosemite Valley, Brewer, Torrey, Bolander; Northern California, A. Wood; Nevada Co., Miss N. J. Davis. This genus, particularly interesting as a transition from the *Hydroleæ* to the proper *Hydrophyllaceæ*, is dedicated to Professor John W. Draper of New York, author of a Treatise on the Forces which produce the Organization of Plants, and of other distinguished physiological and philosophical works. It was first detected by Mr. Lobb (station not recorded), and briefly characterized by Dr. Gray as a *Nama,* without examination of the interior of the ovary of the fragment sent to him by Dr. Hooker. With the corolla and nearly the andrœcium of that genus it combines the gynæcium and seeds of *Phacelia* proper, except that the ovary and pod are two-celled, and the opposite leaves are peculiar. The embryo has not been found, even in apparently full-grown seeds. J. Torrey.

Lepturus Bolanderi, Thurber, MSS.: pusillus; culmo basi vaginato superne folio solitario lineari instructo; ligula elongata acuta; vaginis laxis striatis; spica solitaria basi vaginata; spiculis unifloris; glumis transversis subæqualibus flore vix longioribus; paleis subæqualibus, inferiore basi breviter barbata apice eroso-dentato longius aristata. — Culmi 1 – 5-pollicares, sæpius ad nodum solitarium geniculati. Folium semipollicare. Palea inferior scabra, costa valida in aristum palea ipsa dimidio breviorem producta. — Very distinct from *L. paniculatus,* which is also found in California. Dry gravelly soil, Russian River Valley, California, Bolander. G. Thurber.

Five hundred and eighty-fifth Meeting.

September 10, 1867. — ADJOURNED STATUTE MEETING.

The PRESIDENT in the chair.

The President called the attention of the Academy to the recent decease of Dr. J. Mason Warren and Dr. James Jackson, of the Resident Fellows; of Jeremiah Day, former President of Yale College, of the Associate Fellows; and of Sir William Lawrence, Augustus Boeckh, and Michael Faraday, of the Foreign Honorary Members.

The following paper was presented: —

Upon the Logic of Mathematics. By C. S. PEIRCE.

PART I.

THE object of the present paper is to show that there are certain general propositions from which the truths of mathematics follow syllogistically, and that these propositions may be taken as definitions of the objects under the consideration of the mathematician without involving any assumption in reference to experience or intuition. That there actually are such objects in experience or pure intuition is not in itself a part of pure mathematics.

Let us first turn our attention to the logical calculus of Boole. I have shown in a previous communication to the Academy, that this calculus involves eight operations, viz. Logical Addition, Arithmetical Addition, Logical Multiplication, Arithmetical Multiplication, and the processes inverse to these.

Definitions.

1. *Identity.* $a \mathrel{=\!\!\!,}\, b$ expresses the two facts that any a is b and any b is a.
2. *Logical Addition.* $a \mathbin{+\!\!\!,}\, b$ denotes a member of the class which contains under it all the a's and all the b's, and nothing else.
3. *Logical Multiplication.* $a\,,b$ denotes only whatever is both a and b.
4. *Zero* denotes *nothing*, or the class without extent, by which we mean that if a is any member of any class, $a \mathbin{+\!\!\!,}\, 0$ is a.
5. *Unity*, denotes *being*, or the class without content, by which we mean that, if a is a member of any class, a is $a\,,1$.
6. *Arithmetical Addition.* $a + b$, if $a\,,b \mathrel{=\!\!\!,}\, 0$ is the same as $a \mathbin{+\!\!\!,}\, b$, but, if a and b are classes which have any extent in common, it is not a class.

7. *Arithmetical Multiplication.* $a\, b$ represents an event when a and b are events only if these events are independent of each other, in which case $a\, b =_{,} a\,, b$. By the events being independent is meant that it is possible to take two series of terms, A_1, A_2, A_3, &c., and B_2, B_2, B_3, &c., such that the following conditions will be satisfied. (Here x denotes any individual or class, not nothing; A_{m}, A_{n}, B_{m}, B_{n}, any members of the two series of terms, and ΣA, ΣB, $\Sigma(A, B)$ logical sums of some of the $\mathrm{A_n}$'s, the $\mathrm{B_n}$'s, and the $(A_{\mathrm{n}}, B_{\mathrm{n}})$'s respectively).

Condition 1. No A_{m} is A_{n}.
" 2. No B_{m} is B_{n}.
" 3. $x =_{,} \Sigma(A, B)$
" 4. $a =_{,} \Sigma A$.
" 5. $b =_{,} \Sigma B$.
" 6. Some A_{m} is B_{n}.

From these definitions a series of theorems follow syllogistically, the proofs of most of which are omitted on account of their ease and want of interest.

Theorems.

I.

If $a =_{,} b$, then $b =_{,} a$.

II.

If $a =_{,} b$, and $b =_{,} c$, then $a =_{,} c$.

III.

If $a +_{,} b =_{,} c$, then $b +_{,} a =_{,} c$.

IV.

If $a +_{,} b =_{,} m$ and $b +_{,} c =_{,} n$ and $a +_{,} n =_{,} x$, then $m +_{,} c =_{,} x$.

Corollary. — These last two theorems hold good also for arithmetical addition.

V.

If $a + b =_{,} c$ and $a' + b =_{,} c$, then $a =_{,} a'$, or else there is nothing not b.

This theorem does not hold with logical addition. But from definition 6 it follows that

No a is b (supposing there is any a)

No a' is b (supposing there is any a')

neither of which propositions would be implied in the corresponding formulæ of logical addition. Now from definitions 2 and 6,

Any a is c

$\therefore$ Any a is c not b

But again from definitions 2 and 6 we have

Any c not b is a' (if there is any not b)

$\therefore$ Any a is a' (if there is any not b)

And in a similar way it could be shown that any a' is a (under the same supposition). Hence by definition 1,

$a \underset{,}{=} a'$ if there is anything not b.

Scholium. — In arithmetic this proposition is limited by the supposition that b is finite. The supposition here though similar to that is not quite the same.

VI.

If $a\,,b \underset{,}{=} c$, then $b\,,a \underset{,}{=} c$.

VII.

If $a\,,b \underset{,}{=} m$ and $b\,,c \underset{,}{=} n$ and $a\,,n \underset{,}{=} x$, then $m,\,c \underset{,}{=} x$.

VIII.

If $m\,,n \underset{,}{=} b$ and $a \underset{,}{+} m \underset{,}{=} u$ and $a \underset{,}{+} n \underset{,}{=} v$ and $a \underset{,}{+} b \underset{,}{=} x$, then $u,\,v \underset{,}{=} x$.

IX.

If $m \underset{,}{+} n \underset{,}{=} b$ and $a\,,m \underset{,}{=} u$ and $a\,,n \underset{,}{=} v$ and $a\,,b \underset{,}{=} x$, then $u \underset{,}{+} v \underset{,}{=} x$.

The proof of this theorem may be given as an example of the proofs of the rest.

It is required then (by definition 3) to prove three propositions, viz.

1st. That any u is x.

2d. That any v is x.

3d. That any x not u is v.

First Proposition.

Since $u =_{,} a, m$ by definition 3

Any u is m,

and since $m +_{,} n =_{,} b$ by definition 2

Any m is b,

whence Any u is b,

But since $u =_{,} a, m$ by definition 3

Any u is a,

whence Any u is both a and b,

But since $a, b =_{,} x$ by definition 3

Whatever is both a and b is x

whence Any u is x.

Second Proposition.

This is proved like the first.

Third Proposition.

Since $a, m =_{,} u$ by definition 3,

Whatever is both a and m is u.

or Whatever is not u is not both a and m.

or Whatever is not u is either not a or not m.

or Whatever is not u and is a is not m.

But since $a, b =_{,} x$ by definition 3

Any x is a,

whence Any x not u is not u and is a,

whence Any x not u is not m.

But since $a , b =_{,} x$ by definition 3

Any x is b,

whence Any x not u is b,

Any x not u is b not m.

But since $m +_{,} n =_{,} b$ by definition 2

Any b not m is n,

whence Any x not u is n,

and therefore Any x not u is both a and m.

But since $a , n =_{,} v$ by definition 3

Whatever is both a and u is v,

whence Any x not u is v.

Corollary 1. — This proposition readily extends itself to arithmetical addition.

Corollary 2. — The converse propositions produced by transposing the last two identities of Theorems VIII. and IX. are also true.

Corollary 3. — Theorems VI., VII., and IX. hold also with arithmetical multiplication. This is sufficiently evident in the case of theorem VI., because by definition 7 we have an additional premise, namely, that a and b are independent, and an additional conclusion which is the same as that premise.

In order to show the extension of the other theorems, I shall begin with the following lemma. If a and b are independent, then corresponding to every pair of individuals, one of which is both a and b, there is just one pair of individuals one of which is a and the other b; and conversely, if the pairs of individuals so correspond, a and b are independent. For, suppose a and b independent, then, by definition 7, condition 3, every class (A_m, B_n) is an individual. If then A_a denotes any

A_m which is a, and B_b any B_m which is b, by condition 6 (A_a, B_n) and (A_m, B_b) both exist, and by conditions 4 and 5 the former is any individual a, and the latter any individual b. But given this pair of individuals, both of the pair (A_a, B_b) and (A_m, B_n) exist by condition 6. But one individual of this pair is both a and b. Hence the pairs correspond, as stated above. Next, suppose a and b to be any two classes. Let the series of A_m's be a and not-a; and let the series of B_m's be all individuals separately. Then the first five conditions can always be satisfied. Let us suppose, then, that the sixth alone cannot be satisfied. Then A_p and B_q may be taken such that (A_p, B_q) is nothing. Since A_p and B_q are supposed both to exist, there must be two individuals (A_p, B_n) and (A_m, B_q) which exist. But there is no corresponding pair (A_m, B_n) and (A_p, B_q). Hence, no case in which the sixth condition cannot be satisfied simultaneously with the first five is a case in which the pairs rightly correspond; or, in other words, every case in which the pairs correspond rightly is a case in which the sixth condition can be satisfied, provided the first five can be satisfied. But the first five can always be satisfied. Hence, if the pairs correspond as stated, the classes are independent.

In order to show that Theorem VII. may be extended to arithmetical multiplication, we have to prove that if a and b, b and c, and a and (b,c), are independent, then (a, b) and c are independent. Let s denote any individual. Corresponding to every s with (a, b, c), there is an a and (b, c). Hence, corresponding to every s with s and with (a, b, c) (which is a particular case of that pair), there is an s with a and with (b, c). But for every s with (b, c) there is a b with c; hence, corresponding to every a with s and with (b, c), there is an a with b and with c. Hence, for every s with s and with (a, b, c) there is an a with b and with c. For every a with b there is an s with (a, b); hence, for every a with b and with c, there is an s with (a, b) and c. Hence, for every s with s and with (a, b, c) there is an s with (a, b) and with c. Hence, for every s with (a, b, c) there is an (a, b) with c. The converse could be proved in the same way. Hence, &c.

Theorem IX. holds with arithmetical addition of whichever sort the multiplication is. For we have the additional premise that "No m is n"; whence since "any u is m" and "any v is n," "no u is v," which is the additional conclusion.

Corollary 2, so far as it relates to Theorem IX., holds with arithmetical addition and multiplication. For, since no m is n, every pair, one

of which is a and either m or n, is either a pair, one of which is a and m, or a pair, one of which is a and n, and is not both. Hence, since for every pair one of which is a and m, there is a pair one of which is a and the other m, and since for every pair one of which is a, n there is a pair one of which is a and the other n; for every pair one of which is a and either m or n, there is either a pair one of which is a and the other m, or a pair one of which is a and the other n, and not both; or, in other words, there is a pair one of which is a and the other either m or n.

[It would perhaps have been better to give this complicated proof in its full syllogistic form. But as my principal object is merely to show that the various theorems could be so proved, and as there can be little doubt that if this is true of those which relate to arithmetical addition it is true also of those which relate to arithmetical multiplication, I have thought the above proof (which is quite apodeictic) to be sufficient. The reader should be careful not to confound a proof which needs itself to be experienced with one which requires experience of the object of proof.]

X.

If $a\, b =_{,} c$ and $a'\, b =_{,} c$, then $a =_{,} a'$, or no b exists.

This does not hold with logical, but does with arithmetical multiplication.

For if a is not identical with a', it may be divided thus

$$a =_{,} a\,,\, a' + a\,,\, \bar{a}'$$

if $\bar{a}'$ denotes not a'. Then

$$a\,,\, b =_{,} (a\,,\, a')\,,\, b + (a\,,\, \bar{a}')\,,\, b$$

and by the definition of independence the last term does not vanish unless $(a\,,\, \bar{a}') =_{,} 0$ or all a is a'; but since $a\,,\, b =_{,} a'\,,\, b =_{,} (a\,,\, a')\,,\, b + (\bar{a}\,,\, a')\,,\, b$, this term does vanish, and, therefore, only a is a', and in a similar way it could be shown that only a' is a.

XI.

$1 +_{,} a =_{,} 1.$

This is not true of arithmetical addition, for since by definition 7,

$$1\, x\,,\, 1 =_{,} x\, 1$$

by Theorem IX.

$$x \,,\, (1 \mathbin{+} a) \mathrel{\overset{}{=}}_{,} x\,(1 \mathbin{+} a) \mathrel{=}_{,} x\,1 + x\,a \mathrel{=}_{,} x + x\,a$$

Whence $x\ a =_{,} 0$, while neither x nor a is zero, which, as will appear directly, is impossible.

XII.

$0 \,,\, a =_{,} 0$

Proof. — For call $0 \,,\, a =_{,} x$. Then by definition 3

x belongs to the class *zero*.

$\therefore$ by definition 4 $\qquad x =_{,} 0.$

Corollary 1. — The same reasoning applies to arithmetical multiplication.

Corollary 2. — From Theorem X. and the last corollary it follows that if $a\ b =_{,} 0$, either $a =_{,} 0$ or $b =_{,} 0$.

XIII.

$a \,,\, a =_{,} a.$

XIV.

$a +_{,} a =_{,} a.$

These do not hold with arithmetical operations.

General Scholium. — This concludes the theorems relating to the direct operations. As the inverse operations have no peculiar logical interest, they are passed over here.

In order to prevent misapprehension, I will remark that I do not undertake to demonstrate the principles of logic themselves. Indeed, as I have shown in a previous paper, these principles considered as speculative truths are absolutely empty and indistinguishable. But what has been proved is the *maxims* of logical procedure, a certain system of signs being given.

The definitions given above for the processes which I have termed arithmetical plainly leave the functions of these operations in many cases uninterpreted. Thus if we write

$$a + b \mathrel{\overline{\overline{\tau}}} b + a$$

$$a + (b + c) \mathrel{\overline{\overline{\tau}}} (a + b) + c$$

$$b\,c \mathrel{\overline{\overline{\tau}}} c\,b$$

$$(a\,b)\,c \mathrel{\overline{\overline{\tau}}} a\,(b\,c)$$

$$a\,(m + n) \mathrel{\overline{\overline{\tau}}} a\,m + a\,n$$

we have a series of identities whose truth or falsity is entirely undeterminable. In order, therefore, *fully to define those operations*, we will say that all propositions, equations, and identities which are in the general case left by the former definitions undetermined as to truth shall be true, provided they are so in all interpretable cases.

On Arithmetic.

Equality is a relation of which identity is a species.

If we were to leave equality without further defining it, then by the last scholium all the formal rules of arithmetic would follow from it. And this completes the central design of this paper, as far as arithmetic is concerned.

Still it may be well to consider the matter a little further. Imagine, then, a particular case under Boole's calculus, in which the letters are no longer terms of first intention, but terms of second intention, and that of a special kind. Genus, species, difference, property, and accident, are the well-known terms of second intention. These relate particularly to the *comprehension* of first intentions; that is, they refer to different sorts of predication. Genus and species, however, have at least a secondary reference to the *extension* of first intentions. Now let the letters, in the particular application of Boole's calculus now supposed, be terms of second intention which relate exclusively to the extension of first intentions. Let the differences of the characters of things and events be disregarded, and let the letters signify only the differences of classes as wider or narrower. In other words, the only logical comprehension which the letters considered as terms will have is the greater or less divisibility of the classes. Thus, n in another case of Boole's calculus might, for example, denote "New England State"; but in the case now supposed, all the characters which make these States what they are being neglected, it would signify only what

essentially belongs to a class which has the same relations to higher and lower classes which the class of New England States has, — that is, a collection of *six*.

In this case, the sign of identity will receive a special meaning. For, if m denotes what essentially belongs to a class of the rank of "sides of a cube," then $m \mathrel{=\!\!\!\!,} n$ will imply, not that every New England State is a side of a cube, and conversely, but that whatever essentially belongs to a class of the numerical rank of "New England States" essentially belongs to a class of the rank of "sides of a cube, and conversely. *Identity* of this particular sort may be termed *equality*, and be denoted by the sign $=$.* Moreover, since the numerical rank of a *logical sum* depends on the identity or diversity (in first intention) of the integrant parts, and since the numerical rank of a *logical product* depends on the identity or diversity (in first intention) of parts of the factors, logical addition and multiplication can have no place in this system. Arithmetical addition and multiplication, however, will not be destroyed. $a\,b = c$ will imply that whatever essentially belongs at once to a class of the rank of a, and to another independent class of the rank of b belongs essentially to a class of the rank of c, and conversely. $a + b = c$ implies that whatever belongs essentially to a class which is the logical sum of two mutually exclusive classes of the ranks of a and b belongs essentially to a class of the rank of c, and conversely. It is plain that from these definitions the same theorems follow as from those given above. *Zero* and *unity* will, as before, denote the classes which have respectively no extension and no comprehension; only the comprehension here spoken of is, of course, that comprehension which alone belongs to letters in the system now considered, that is, this or that degree of divisibility; and therefore *unity* will be what belongs essentially to a class of any rank independent of its divisibility. These two classes alone are common to the two systems, because the first intentions of these alone determine, and are determined by, their second intentions. Finally, the laws of the Boolian

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* Thus, in one point of view, *identity* is a species of *equality*, and, in another, the reverse is the case. This is because the Being of the copula may be considered on the one hand (with De Morgan) as a special description of "inconvertible, transitive relation," while, on the other hand, all relation may be considered as a special determination of being. If a Hegelian should be disposed to see a contradiction here, an accurate analysis of the matter will show him that it is only a verbal one.

calculus, in its ordinary form, are identical with those of this other so far as the latter apply to *zero* and *unity*, because every class, in its first intention, is either without any extension (that is, is nothing), or belongs essentially to that rank to which every class belongs, whether divisible or not.

These considerations, together with those advanced on page 293 (§ 12) of this volume, will, I hope, put the relations of logic and arithmetic in a somewhat clearer light than heretofore.

Five hundred and eighty-sixth Meeting.

October 8, 1867. — MONTHLY MEETING.

The CORRESPONDING SECRETARY in the chair.

The Corresponding Secretary read letters relative to exchanges; also a letter from Major-General Sabine in acknowledgment of his election as Foreign Honorary Member of the Academy.

The Corresponding Secretary announced the recent decease of Hon. Charles G. Loring, of the Resident Fellows.

Dr. C. G. Putnam presented the meteorological observations of the late Dr. Jackson.

Professor Lovering presented for Professor Treadwell the following paper: —

Corrections to a Paper "On the Comparative Strength of Cannon of Modern Construction," published in Vol. VII. of the Proceedings of the Academy. By DANIEL TREADWELL.

IN a paper "On the Comparative Strength of Cannon of Modern Construction," written by me in January, 1866, communicated to the Academy in September of the same year, and published in the last volume (the seventh) of our Proceedings, I, by some inadvertence for which I am now unable to account, in computing the force of the 600 pounder, or 13·3-inch coil gun, as constructed by Armstrong, described it as capable of bearing a charge of 100 pounds of powder.

Although this quantity of powder was no doubt fired in it, I know not how many times, yet it ought not by any means to be rated as its *service charge;* and I recognize it as an oversight in me to have taken

it as such. In fact, I have no belief that more than 70 pounds of powder should be assigned as the service charge of the Armstrong 13·3-inch gun; as no gun can be trusted for long-continued firing with more than $\frac{70}{100}$ of the largest charge of powder which it may have withstood, and no *cast-iron* gun with so much as this.

I have not the data necessary to determine accurately the velocity, and consequently the force, which this reduction of the charge of powder must make in the shot; but if we take the force of the shot in the direct ratio of the weight of the charge of powder, we shall have 261, instead of 372·8, as representing the "number of pounds of shot raised one foot by each pound of metal in the gun," as these numbers are in the ratio of 70 to 100.

I am not able to state what has constituted the greatest charge of powder borne by Armstrong's gun of 12 tons, carrying a shot of 300 pounds; but reducing the charge of 60 pounds, as given by me in the ratio of 70 to 100, we have a charge of 42 instead of 60 pounds of powder, and a consequent reduction of the force of the gun from 392 "foot pounds" to 273 "foot pounds."

I have thought it the more necessary to make this correction, as in a computation of the force of the Dahlgren and Rodman guns, given in the same paper to which this is a correction, the quantity of powder then understood by me from all that had been published by government authority as constituting a service charge was taken as one of the factors in assigning the measure of the force to those guns. It is now claimed, however, to have been discovered that the Rodman gun is capable of withstanding much larger charges of powder than were authorized to be used when my paper was communicated to the Academy.

Professor Lovering made the following remarks on the Optical Method of studying Sound, illustrating the subject by many experiments: —

When the science of Acoustics is studied by means of the ear exclusively, we judge of the process simply by the result, that is, by the sensation. The optical method of investigation often gives us an insight into the process itself. Sound begins with a stationary vibration in the sonorous body; it is propagated by a progressive undulation; and it ends, physically and mechanically considered, in a vibration of some one of the three thousand nervous filaments discovered by Corti in

the labyrinth of the human ear. Whether we regard the sound, therefore, at its origin, in its promulgation, or in the sensation, it is nothing but a vibration; and vibration is motion, and motion is the subject of vision. So that to see sound is only to see the motions which cause it. The only difficulty in seeing sound lies in the fact that the acoustic vibrations are upon a microscopic scale of magnitude, and, by their quick succession, the separate effects of individual vibrations blend into one sensation, in the eye as well as in the ear, by virtue of what is called in both cases the persistency of the impression on the organ of sensation. To overcome the first difficulty a beam of light is reflected from the vibrating body, or a mirror attached to it, which moves *in angle* twice as fast as the body itself, while the motion *in arc* may be amplified to any extent by increasing the length of the beam of light. The second difficulty is surmounted by reflecting the vibrations of the sonorous body itself, or some more visible effect which they originate, from a revolving mirror. By this device of looking at the image of the body, instead of the body itself, its vibrations, which coexist in space, are disentangled from each other, and individual vibrations, hundreds of which succeed each other in a single second of time, are translated into a long belt of space, in which even two successive ones do not overlap.

The optical method of studying sound embraces, in general, Savart's contrivance for discovering and exhibiting the nodal lines of plates by means of sand sprinkled over their surface, the investigation of the nodes and bellies of sounding strings by mounted riders, and of columns of air by a little drumhead suspended in the pipes, and, more recently, Lissajous's mirrors attached to tuning-forks, etc., Kœnig's flames played upon by vibrating columns of air and reflected in a revolving mirror, and, finally, Melde's strings excited by the sympathetic vibration of an attached tuning-fork or bell.

The present communication is confined, however, to Kœnig's reflected flames, in which are seen the individual vibrations of an organ-pipe; by which can be beautifully demonstrated to the eye: First, — That the number of vibrations increases with the audible pitch; Second, — That coexisting vibrations produce maxima and minima of motion corresponding to the beats which are recognized by the ear; Third, — That one column of air will respond, in sympathetic vibration, to another, when there is an agreement between their fundamental notes or some of their harmonics; Fourth, That two unison-pipes, brought

into intimate neighborhood, will move so that the vibrations of the air cross one another and produce silence, as Savart showed experimentally in the case of pendulums of equal length vibrating in company.

This peculiar case of unison-pipes I have made a subject of special investigation. In complex cases, it would doubtless be impossible so to arrange the voices and instruments that the total volume of sound should be multiplied in the same ratio as the number of performers. The effect of a large chorus or a large orchestra will disappoint expectation, from the unavoidable interferences of sound-waves. But, in the simple case of two unison-pipes, can they be prevented from silencing each other? The remedy for the evil would be: First,— To sacrifice in a measure the perfection of the unison; or, Second,— To place them at a distance beyond each other's influence; or, Third, — To separate them by one half of the wave-length which propagates a sound of the given pitch, or by some odd multiple of that quantity. The latter remedy would answer for auditors in the direction of the line which united the two pipes, though not for the audience generally. In studying the effect of position, I have made the following experiments, the ear being the judge; or the eye, looking at the broken ribbon of light in the revolving mirror.

I. The pipes are placed side by side.

1. With similar ends together, they silence each other.
2. With dissimilar ends together, they silence each other.

II. The pipes are placed with their axes upon the same straight line.

1. If similar ends are together, whichever of the two ends be selected, they silence one another.
2. If dissimilar ends are together, they silence each other.

III. The pipes are placed at right angles to one another, with one extremity of each pipe at the angle.

1. If the ends that are played are at the angle, the pipes re-enforce each other.
2. If the other ends are at the angle, they tend to silence each other.
3. If dissimilar ends are at the angle, they re-enforce each other.

In all these experiments, the pipes employed were open at both ends.

Now that science is in possession of this delicate optical method, which requires for its success no nice musical ear, other problems, heretofore settled by assumption, may be brought within the range of demonstration.

Five hundred and eighty-seventh Meeting.

November 13, 1867. — STATUTE MEETING.

The PRESIDENT in the chair.

The President announced the decease of Professor Mittermaier, of the Foreign Honorary Members.

Professor Lovering announced that Vol. IX. Part I. of the Memoirs, was ready for distribution.

Professor Edward C. Pickering was elected a Resident Fellow in Class I. Section 3.

Dr. C. H. F. Peters was elected an Associate Fellow in Class I. Section 2.

On the motion of Dr. G. E. Ellis, the Rumford Committee was instructed to collect papers relating to the life of Count Rumford.

The following paper was presented: —

Upon Logical Comprehension and Extension. By C. S. PEIRCE.

§ 1. *That these Conceptions are not so Modern as has been represented.*

THE historical account usually given of comprehension and extension is this, "that the distinction, though taken in general terms by Aristotle, and explicitly announced with scientific precision by one, at least, of his Greek commentators, had escaped the marvellous acuteness of the schoolmen, and remained totally overlooked and forgotten till the publication of the Port Royal Logic." * I would offer

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* This is quoted from Baines (Port Royal Logic, 2d ed. p. xxxiii.), who says that he is indebted to Sir William Hamilton for the information.

the following considerations to show that this interpretation of history is not exactly true. In the first place, it is said that a distinction was taken between these attributes, as though they were previously confounded. Now there is not the least evidence of this. A German logician, has, indeed, by a subtle misconception, considered extension as a species of comprehension, but, to a mind beginning to reflect, no notions seem more unlike. The mental achievement has been the bringing of them into relation to one another, and the conception of them as factors of the import of a term, and not the separation of them. In the second place it is correctly said that the doctrine taught by the Port Royalists is substantially contained in the work of a Greek commentator. That work is no other than Porphyry's Isagoge * ; and therefore it would be most surprising if the doctrine had been totally overlooked by the schoolmen, for whether their acuteness was as marvellous as Hamilton taught or not, they certainly studied the commentary in question as diligently as they did the Bible. It would seem, indeed, that the tree of Porphyry involves the whole doctrine of extension and comprehension except the names. Nor were the scholastics without names for these quantities. The *partes subjectives* and *partes essentiales* are frequently opposed; and several other synonymes are mentioned by the Conimbricenses. It is admitted that Porphyry fully enunciates the doctrine; it must also be admitted that the passage in question is fully dealt with and correctly explained by the mediæval commentators. The most that can be said, therefore, is that the doctrine of extension and comprehension was not a prominent one in the mediæval logic. †

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* Porphyry appears to refer to the doctrine as an ancient one.

† The author of "De Generibus et Speciebus" opposes the *integral* and *diffinitive* wholes. John of Salisbury refers to the distinction of comprehension and extension, as something "quod fere in omnium ore celebre est, aliud scilicet esse quod appellativa *significant*, et aliud esse quod *nominant*. Nominantur singularia, sed universalia significantur." (Metalogicus, lib. 2, cap. 20. Ed. of 1620, p. 111.)

Vincentius Bellovacensis (*Speculum Doctrinale*, Lib. III. cap. xi.) has the following: "Si vero quæritur utrum hoc universale 'homo' sit in quolibet homine secundum se totum an secundem partem, dicendum est quod secundum se totum, id est secundum quamlibet sui partem diffinitivam. . . . . Non autem secundum quamlibet partem subjectivam." William of Auvergne (Prantl's *Geschichte*, Vol. III. p. 77) speaks of "totalitatem istam, quæ est ex partibus rationis seu diffinitionis, et hae partes sunt genus et differentiæ; alio modo partes speciei individua sunt, quoniam ipsam speciem, cum de eis prædicatur, sibi invicem quodammodo partiunter."

A like degree of historical error is commonly committed in reference to another point which will come to be treated of in this paper, allied, at least, as it is most intimately, with the subject of comprehension and extension, inasmuch as it also is founded on a conception of a term as a whole composed of parts, — I mean the distinction of clear and distinct. Hamilton tells us "we owe the discrimination to the acuteness of the great Leibniz. By the Cartesians the distinction had not been taken; though the authors of the Port Royal Logic came so near that we may well marvel how they failed explicitly to enounce it." (Lectures on Logic; Lecture IX.) Now, in fact, all that the Port Royalists say about this matter * is copied from Descartes,† and their variations from his wording serve only to confuse what in him is tolerably distinct. As for Leibniz, he himself expressly avows that the distinction drawn by Descartes is the same as his own. ‡ Nevertheless, it is very much more clear with Leibniz than with Descartes. A philosophical distinction emerges gradually into consciousness; there is no moment in history before which it is altogether unrecognized, and after which it is perfectly luminous. Before Descartes, the distinction of confused and distinct had been thoroughly developed, but the difference between distinctness and clearness is uniformly overlooked. Scotus distinguishes between conceiving confusedly and conceiving the confused, and since any obscure concept necessarily includes more than its proper object, there is always in what is obscurely conceived a conception of something confused; but the schoolmen came no nearer than this to the distinction of Descartes and Leibniz.

§ 2. *Of the Different Terms applied to the Quantities of Extension and Comprehension.*

Extension and comprehension are the terms employed by the Port Royalists. Owing to the influence of Hamilton, *intension* is now frequently used for comprehension; but it is liable to be confounded with intensity, and therefore is an objectionable word. It is derived from the use of cognate words by Cajetan and other early writers. *External* and *internal quantity* are the terms used by many early Kantians.

If we were to go to later authors, the examples would be endless. See any commentary in Phys. Lib. I.

* Part I. chap. ix.

† *Principia*, Part I. § 45 *et seq.*

‡ Eighth Letter to Burnet.

Scope and *force* are proposed by De Morgan. *Scope* in ordinary language expresses extension, but *force* does not so much express comprehension as the power of creating a lively representation in the mind of the person to whom a word or speech is addressed. Mr. J. S. Mill has introduced the useful verbs *denote* and *connote*, which have become very familiar. It has been, indeed, the opinion of the best students of the logic of the fourteenth, fifteenth, and sixteenth centuries, that *connotation* was in those ages used exclusively for the reference to a second significate, that is (nearly) for the reference of a relative term (such as *father*, *brighter*, &c.) to the correlate of the object which it primarily denotes, and was never taken in Mill's sense of the reference of a term to the essential characters implied in its definition. § Mr. Mill has, however, considered himself entitled to deny this upon his simple authority, without the citation of a single passage from any writer of that time. After explaining the sense in which he takes the term *connote*, he says: "The schoolmen, to whom we are indebted for the greater part of our logical language, gave us this also, and in this very sense. For though some of their general expressions countenance the use of the word in the more extensive and vague acceptation in which it is taken by Mr. [James] Mill, yet when they had to define it specifically as a technical term, and to fix its meaning as such, with that admirable precision which always characterized their definitions, they clearly explained that nothing was said to be connoted except *forms*, which word may generally, in their writings, be understood as synonymous with *attributes*." As scholasticism is usually said to come to an end with Occam, this conveys the idea that *connote* was commonly employed by earlier writers. But the celebrated Prantl considers it conclusive proof that a passage in Occam's *Summa* is spurious, that *connotative* is there spoken of as a term in frequent use; * and remarks upon a passage of Scotus in which *connotatum* is found, that this conception is here met with for the first time. † The term occurs, however, in Alexander of Ales, ‡ who makes *nomen connotans* the equivalent of *appellatio relativa*, and takes the relation itself as the object of *connotare*, speaking of creator as connoting the relation of

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* Prantl, *Geschichte*, Vol. III. p. 364.

† Ibid. p. 134. Scotus also uses the term. *Quodlib.* question 13, article 4.

‡ *Summa Theologica*, Part I. question 53.

§ Cf. Morin, *Dictionnaire*, Tome I. col. 684; Chauvin, *Lexicon*, both editions; Eustachius, *Summa*, Part I. Tr. I. qu. 6.

creator to creature. Occam's *Summa* * contains a chapter devoted to the distinction of absolute and connotative names. The whole deserves to be read, but I have only space to quote the following: "Nomen autem connotativum est illud quod significat aliquid primario et aliquid secundario; et tale nomen proprie habet diffinitionem exprimentem quid nominis et frequenter oportet ponere aliquid illius diffinitionis in recto et aliud in obliquo; sicut est de hoc nomine album, nam habet diffinitionem exprimentem quid nominis in qua una dictio ponitur in recto et alia in obliquo. Unde si queratur quid significat hoc nomen album, dices quod idem quod illa oratio tota 'aliquid informatum albedine' vel 'aliquid habens albedinem' et patet quod una pars orationis istius ponitur in recto et alia in obliquo..... Huiusmodi autem nomina connotativa sunt omnia nomina concreta primo modo dicta, et hoc *quia talia concreta significant unum in recto et aliud in obliquo,* hoc est dictu, in diffinitione exprimente quid nominis debet poni unus rectus significans unam rem et alius obliquus significans aliam rem, sicut patet de omnibus talibus, iustus, albus, animatus, et sic de aliis. Huiusmodi etiam nomina sunt omnia nomina relatiua, quia semper in eorum diffinitionibus ponuntur diversa idem diuersis modis vel diuersa significantia, sicut patet de hoc nomine simile. Mere autem absoluta sunt illa quæ non significant aliquid principaliter et aliud vel idem secundario, sed quicquid significatur per tale nomen æque primo significatur sicut patet de hoc nomine animal." Eckius, in his comment on Petrus Hispanus, has also some extended remarks on the signification of the term *connote,* which agree in the main with those just quoted.† Mr. Mill's historical statement cannot, therefore, be admitted.

Sir William Hamilton has borrowed from certain late Greek writers the terms *breadth* and *depth,* for extension and comprehension respectively. ‡ These terms have great merits. They are brief; they are suited to go together; and they are very familiar. Thus, "wide" learning is, in ordinary parlance, learning of many things; "deep" learning, much knowledge of some things. I shall, therefore, give the preference to these terms. Extension is also called *sphere* and *circuit;* and comprehension, *matter* and *content.*

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* Part I. chap. X. (Ed. of 1488, fol. 6, c.)

† Fol. 23. d. See also Tatareti Expositio in Petr. Hisp. towards the end. Ed. of 1509, fol. 91, b.

‡ Logic, p. 100. In the *Summa Logices* attributed to Aquinas, we read: "Omnis forma sub se habens multa, idest quod universaliter sumitur, habet quandam *latitudinem;* nam invenitur in pluribus, et dicitur de pluribus." (Tr. 1, c. 3.)

§ 3. *Of the Different Senses in which the Terms Extension and Comprehension have been accepted.*

The terms *extension* and *comprehension*, and their synonymes, are taken in different senses by different writers. This is partly owing to the fact that while most writers speak only of the extension and comprehension of concepts, others apply these terms equally to concepts and judgments (Rösling), others to any mental representation (Überweg and many French writers), others to cognition generally (Baumgarten), others to "terms" (Fowler, Spalding), others to names (Shedden), others to words (McGregor), others to "meanings" (Jevons), while one writer speaks only of the extension of *classes* and the comprehension of *attributes* (De Morgan in his Syllabus).

Comprehension is defined by the Port Royalists as "those attributes which an idea involves in itself, and which cannot be taken away from it without destroying it."

It will be remembered that the *marks* of a term are divided by logicians first into the necessary and the accidental, and that then the necessary marks are subdivided into such as are strictly essential, that is, contained in the definition, and such as are called proper. Thus it is an essential mark of a triangle to have three sides; it is a proper mark to have its three angles equal to two right angles; and it is an accidental mark to be treated of by Euclid.

The definition of the Port Royalists, therefore, makes comprehension include all necessary marks, whether essential or proper.

The Port Royalists attribute comprehension immediately to any ideas. Very many logicians attribute it immediately only to concepts. Now a concept, as defined by them, is strictly only the essence of an idea; they ought therefore to include in the comprehension only the essential marks of a term. These logicians, however, abstract so entirely from the real world, that it is difficult to see why these essential marks are not at the same time all the marks of the object as they suppose it.

There can, I think, be no doubt that such writers as Gerlach and Sigwart make comprehension include all marks, necessary or accidental, which are universally predicable of the object of the concept.

Again, most German writers regard the comprehension as a sum either of concepts (Drobisch, Bachmann, etc.) or of elements of intuition (Trendelenburg). But many English writers regard it as the

sum of real external attributes (Shedden, Spalding, Devey, De Morgan, Jevons, McGregor, Fowler).

According to most writers, comprehension consists of the (necessary) attributes *thought* as common to the objects. Shedden defines it as consisting of all the attributes common to the things denoted.

Again, most logicians consider as marks only such as are virtually * predicated; a few, perhaps, only such as are actually thought, and still fewer include those which are habitually thought. Here and there is found an author who makes comprehension include all true attributes, whether thought or not.

There is also a difference in the mode of reckoning up the marks. Most writers count all distinguishable marks, while a few consider co-extensive marks as the same.

In the use of the term "extension" the want of a definite convention is still more marked. The Port Royalists define it as "those *subjects* to which the idea applies." It would appear, therefore, that it might include mere fictions.

Others limit the term to *real* species, and at the same time extend it to single beings. This is the case with Watts, and also with Friedrich Fischer.

Others are most emphatic in declaring that they mean by it *things*, and not species, real or imaginary. This is the case with Bachmann, Esser, and Schulze.

Others make it include neither concepts nor things, but singular representations. This is the case with the strict Kantian.

The following table exhibits this diversity: —

Extension embraces

Individual representations	according to	Kant, E. Reinhold, etc.
Representations	" "	Fries, Überweg, etc.
Real external things and species	" "	Watts, Shedden, etc.
Real external individual objects	" "	Bachmann, Devey, etc.
Things	" "	Schulze, Bowen, etc.
Species	" "	Drobisch, De Morgan, etc.
Objects (representations)	" "	Thomson, etc.
Individuals	" "	Mahan.
Concepts	" "	Herbart, Vorländer, etc.
General terms	" "	Spalding.
Psychical concepts	" "	Strümpell.
Variable marks	" "	Ritter.

* I adopt the admirable distinction of Scotus between actual, habitual, and virtual cognition.

Again, logicians differ as to whether by extension they mean the concepts, species, things, or representations to which the term is habitually applied in the judgment, or all to which it is truly applicable. The latter position is held by Herbart, Kiesewetter, etc.; the former by Duncan, Spalding, Vorländer, Überweg, etc.

Some logicians include only *actual* things, representations, etc., under extension (Bachmann, Fries, Herbart); others extend it to such as are merely possible (Esser, Ritter, Gerlach).

Finally, some few logicians speak of the two quantities as numerical, while most writers regard them as mere aggregates of diverse objects or marks.

§ 4. *Denials of the Inverse Proportionality of the two Quantities, and Suggestions of a third Quantity.*

Until lately the law of the inverse proportionality of extension and comprehension was universally admitted. It is now questioned on various grounds.

Drobisch says that the comprehension varies arithmetically, while the extension varies geometrically. This is true, in one sense.

Lotze, after remarking that the only conception of a universal which we can have is the power of imagining singulars under it, urges that the possibility of determining a concept in a way corresponding to each particular under it is a mark of that concept, and that therefore the narrower concepts have as many marks as the wider ones. But, I reply, *these* marks belong to the concept in its second intention, and are not common marks of those things to which it applies, and are therefore no part of the comprehension. They are, in fact, the very marks which constitute the extension. No one ever denied that extension is a mark of a concept; only it is a certain mark of second intention.

Vorländer's objection is much more to the purpose. It is that if from any determinate notion, as that of Napoleon, we abstract all marks, all determination, what remains is merely the conception *something*, which has no more extension than Napoleon. "Something" has an uncertain sphere, meaning either this thing or that or the other, but has no general extension, since it means one thing only. Thus, before a race, we can say that some horse will win, meaning this one, that one, or that one; but by some horse we mean but one, and it therefore has no more extension than would a term definitely indicating which, — although this latter would be more determinate, that is, would have

more comprehension. I am not aware that those who adhere to Kant's unmodified doctrine have succeeded in answering this objection.

Überweg has the following remarks.* "To the higher representation, since conformably to its definition it contains only the common elements of content of several lower representations, belongs in comparison to each of the lower a more limited content, but a wider circuit. The lower representation, on the contrary, has a richer content but narrower circuit. Yet by no means by every diminution or increase of a given content does the circuit increase or diminish, nor by every increase or diminution of a given circuit does the content diminish or increase." I am surprised that he does not explain himself further upon this point, which it is the principal object of this paper to develop.

De Morgan says: † "According to such statements as I have seen, 'man residing in Europe, drawing breath north of the equator, seeing the sun rise before those in America,' would be a more intensively quantified notion than 'man residing in Europe'; but certainly not less *extensive*, for the third and fourth elements of the notion must belong to those men to whom the first and second belong." Mr. De Morgan adopts the definitions of extension and comprehension given by the Port Royalists. According to those definitions, if the third and fourth elements necessarily belong to the notion to which the first and second belong, they are parts of the comprehension of that second notion which is composed of the first and second elements, and therefore the two notions are equal in comprehension; but if this is not the case, then the second notion can be predicated of subjects of which the first cannot, for example, of "man residing in Europe drawing breath south of the Equator"; for that there is really no such man will not affect the truth of the proposition, and therefore the second notion is more extensive than the first.

Two logicians, only, as far as I remember, Archbishop Thomson ‡ and Dr. W. D. Wilson, § while apparently admitting Kant's law, wish to establish a third quantity of concepts. Neither gentleman has defined his third quantity, nor has stated what its relations to the other two are. Thomson calls his Denomination. It seems to be the same as Extension regarded in a particular way. Dr. Wilson terms his new quantity Protension; it has something to do with time, and appears to be generally independent of the other two. It is plain, indeed, that as

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* Logik, 2te Aufl. § 54.

† Formal Logic, p. 234. His doctrine is different in the Syllabus.

‡ Laws of Thought, 4th ed., §§ 52, 80.

§ Logic, Part I. chap. ii. § 5.

long as Kant's law holds, and as long as logical quantities can only be compared as being more or less and not directly measured, and as long as the different *kinds* of quantity cannot be compared at all, a third quantity must be directly proportional to one or other of the known quantities, and therefore must measure the same thing, or else must be independent of the other two, and be quite unconnected with them.

§ 4. *Three Principal Senses in which Comprehension and Extension will be taken in this Paper.*

I shall adopt Hamilton's terms, *breadth* and *depth*, for extension and comprehension respectively, and shall employ them in different senses, which I shall distinguish by different adjectives.

By the *informed breadth* of a term, I shall mean all the real things of which it is predicable, with logical truth on the whole in a supposed state of information. By the phrase "on the whole" I mean to indicate that all the information at hand must be taken into account, and that those things of which there is not on the whole reason to believe that a term is truly predicable are not to be reckoned as part of its breadth.

If T be a term which is predicable only of S', S'', and S''', then the S''s, the S'''s, and the S''''s, will constitute the informed breadth of T. If at the same time, S' and S'' are the subjects of which alone another term T' can be predicated, and if it is not known that all S''''s are either S' or S'', then T is said to have a greater informed breadth than T'. If the S''''s are known not to be all among the S''s and S'''s, this excess of breadth may be termed *certain*, and, if this is not known, it may be termed *doubtful*. If there are known to be S''''s, not known to be S''s or S'''s, T is said to have a greater *actual* breadth than T'; but if no S''''s are known except such are known to be S''s, and S'''s (though there may be others), T is to have a greater *potential* breadth than T'. If T and T' are conceptions in different minds, or in different states of the same mind, and it is known to the mind which conceives T that every S''' is either S'' or S', then T is said to be more *extensively distinct* than T'.*

By the informed depth of a term, I mean all the real characters (in contradistinction to mere names) which can be predicated of it † (with

* For the distinction of extensive and comprehensive distinctness, see Scotus, i. dist. 2. qu. 3.

† That is, of whatever things it is applicable to.

logical truth, on the whole) in a supposed state of information; no character being counted twice over knowingly in the supposed state of information. The depth, like the breadth, may be certain or doubtful, actual or potential, and there is a comprehensive distinctness corresponding to extensive distinctness.

The informed breadth and depth suppose a state of information which lies somewhere between two imaginary extremes. These are, first, the state in which no fact would be known, but only the meaning of terms; and, second, the state in which the information would amount to an absolute intuition of all there is, so that the things we should know would be the very substances themselves, and the qualities we should know would be the very concrete forms themselves. This suggests two other sorts of breadth and depth corresponding to these two states of information, and which I shall term respectively the *essential* and the *substantial* breadth and depth.

By the *essential depth* of a term, then, I mean the really conceivable qualities predicated of it in its definition.

The defined term will not perhaps be applicable to any real objects whatever. Let, for example, the definition of the term T be this,

$$\text{Any T is both } P' \text{ and } P'' \text{ and } P''',$$

then this sums up its whole meaning; and, as it may not be known that there is any such thing as P', the meaning of T does not imply that it exists. On the other hand, we know that neither P', P'', nor P''' is coextensive with the whole sphere of being. For they are determinate qualities, and it is the very meaning of being that it is indeterminate, that is, is more extensive than any determinate term. In fact, P', for example, is a real notion which we never could have except by means of its contrast to something else. Hence we must know that

$$\text{Whatever is not-}P' \text{ is not-T},$$

$$\text{Whatever is not-}P'' \text{ is not-T},$$

and

$$\text{Whatever is not-}P''' \text{ is not T}.$$

Thus if we define the *essential breadth* of a term as those real things of which, according to its very meaning, a term is predicable, not-T has an essential breadth. We may therefore divide all terms into two classes, the essentially affirmative or positive and the essentially

negative; of which the former have essential depth, but no essential breadth, and the latter essential breadth, but no essential depth. It must be noted, however, that this division is not the same as the similar one which language makes. For example, *being*, according to this, is an essentially negative term, inasmuch as it means that which can be predicated of whatever you please, and so has an essential breadth; while *nothing* is an essentially positive term, inasmuch as it means that of which you are at liberty to predicate what you please, and therefore has an essential depth. The essential subjects of being cannot be enumerated, nor the essential predicates of nothing.

In essential breadth or depth, no two terms can be equal; for, were that the case, the two terms would have the same meaning, and therefore, for logical purposes, would be the same term. Two terms may have unknown relations in these quantities, on account of one or other of them not being distinctly conceived.

Substantial breadth is the aggregate of real substances of which alone a term is predicable with absolute truth. *Substantial depth* is the real concrete form which belongs to everything of which a term is predicable with absolute truth.

General terms denote several things. Each of these things has in itself no qualities, but only a certain concrete form which belongs to itself alone. This was one of the points brought out in the controversy in reference to the nature of universals.* As Sir William Hamilton says, not even the humanity of Leibniz belongs to Newton, but a different humanity. It is only by abstraction, by an oversight, that two things can be said to have common characters. Hence, a general term has no *substantial depth*. On the other hand, particular terms, while they have *substantial depth*, inasmuch as each of the things, one or other of which are predicated of them, has a concrete form, yet have no *substantial breadth*, inasmuch as there is no aggregate of things to which alone they are applicable. In order to place this matter in a clearer light, I must remark, that I, in common with most logicians, take the copula in the sense of a sign of attribution, and not, like Hamilton, in the sense of a sign of equality in extension or comprehension. He exposes the proposition, "man is an animal," thus: —

The extension of man	*Subject.*
equals	*Copula.*
a part or all of the extension of animal	*Predicate.*

* See, for example, *De Generibus et Speciebus*, p. 548.

And thus he makes the predicate particular. Others interpret it thus: —

Every man	*Subject.*
has all the attributes common to	*Copula.*
every animal	*Predicate.*

It is in this latter sense that the copula is considered in this paper. Now, a particular is, as has been said, an *alternative* subject. Thus, "Some S is M" means, if S', S'', and S''' are the singular S's, that "either S', or else S'', or else S''', has all the attributes belonging to M." A particular term, then, has a substantial depth, because it may have a predicate which is absolutely concrete, as in the proposition, "Some man is Napoleon." But if we put the particular into the predicate we have such a proposition as this: "M has all the attributes belonging to S', or else all those belonging to S'', or else all those belonging to S'''." And this can never be true unless M is a single individual. Now a single individual substance is, I will not say an atom, but the smallest part of an atom, that is, nothing at all. So that a particular can have no *substantial breadth*. Now take the universal term "S." We can say, "Any S is M," but not if M is a real concrete quality. We cannot say, for instance, "Any man is Napoleon." On the other hand, we can say "Any M is S," even if M is a real substance or aggregate of substances. Hence a universal term has no *substantial depth*, but has *substantial breadth*. We may therefore divide all terms into substantial universals and substantial particulars.

Two terms may be equal in their substantial breadth and depth, and differ in their essential breadth and depth. But two terms cannot have relations of substantial breadth and depth which are unknown in the state of information supposed, because in that state of information everything is known.

In informed breadth and depth, two terms may be equal, and may have unknown relations. Any term, affirmative or negative, universal or particular, may have informed breadth or depth.

§ 5. *The Conceptions of Quality, Relation, and Representation, applied to this Subject.*

In a paper presented to the Academy last May, I endeavored to show

that the three conceptions of reference to a ground, reference to a correlate, and references to an interpretant, are those of which logic must principally make use. I there also introduced the term "symbol," to include both concept and word. Logic treats of the reference of symbols in general to their objects. A symbol, in its reference to its object, has a triple reference: —

1st., Its direct reference to its object, or the real things which it represents;

2d., Its reference to its ground through its object, or the common characters of those objects;

3d., Its reference to its interpretant through its object, or all the facts known about its object.

What are thus referred to, so far as they are known, are: —

1st., The informed *breadth* of the symbol;

2d., The informed *depth* of the symbol;

3d., The sum of synthetical propositions in which the symbol is subject or predicate, or the *information* concerning the symbol.

By breadth and depth, without an adjective, I shall hereafter mean the informed breadth and depth.

It is plain that the breadth and depth of a symbol, so far as they are *not* essential, measure the *information* concerning it, that is, the synthetical propositions of which it is subject or predicate. This follows directly from the definitions of breadth, depth, and information. Hence it follows: —

1st., That, as long as the information remains constant, the greater the breadth, the less the depth;

2d., That every increase of information is accompanied by an increase in depth or breadth, independent of the other quantity;

3d., That, when there is no information, there is either no depth or no breadth, and conversely.

These are the true and obvious relations of breadth and depth. They will be naturally suggested if we term the information the *area*, and write —

$$\text{Breadth} \times \text{Depth} = \text{Area.}$$

If we learn that S is P, then, as a general rule, the depth of S is increased without any decrease of breadth, and the breadth of P is increased without any decrease of depth. Either increase may be *certain* or *doubtful*.

It may be the case that either or both of these increases does not take place. If P is a negative term, it may have no depth, and therefore adds nothing to the depth of S. If S is a particular term, it may have no breadth, and then adds nothing to the breadth of P. This latter case often occurs in metaphysics, and, on account of not-P as well as P being predicated of S, gives rise to an appearance of contradiction where there really is none; for, as a contradiction consists in giving to contradictory terms some breadth in common, it follows that, if the common subject of which they are predicated has no real breadth, there is only a verbal, and not a real contradiction. It is not really contradictory, for example, to say that a boundary is both within and without what it bounds. There is also another important case in which we may learn that "S is P," without thereby adding to the depth of S or the breadth of P. This is when, in the very same act by which we learn that S is P, we also learn that P was covertly contained in the previous depth of S, and that consequently S was a part of the previous breadth of P. In this case, P gains in extensive distinctness and S in comprehensive distinctness.

We are now in condition to examine Vorländer's objection to the inverse proportionality of extension and comprehension. He requires us to think away from an object all its qualities, but not, of course, by thinking it to be without those qualities, that is, by denying those qualities of it in thought. How then? Only by supposing ourselves to be ignorant whether it has qualities or not, that is, by diminishing the supposed information; in which case, as we have seen, the depth can be diminished without increasing the breadth. In the same manner we can suppose ourselves to be ignorant whether any American but one exists, and so diminish the breadth without increasing the depth.

It is only by confusing a movement which is accompanied with a change of information with one which is not so, that people can confound generalization, induction, and abstraction. *Generalization* is an increase of breadth and a decrease of depth, without change of information. *Induction* is a certain increase of breadth without a change of depth, by an increase of believed information. *Abstraction* is a decrease of depth without any change of breadth, by a decrease of conceived information. *Specification* is commonly used (I should say unfortunately) for an increase of depth without any change of breadth, by an increase of asserted information. *Supposition* is used for the

same process when there is only a conceived increase of information. *Determination*, for any increase of depth. *Restriction*, for any decrease of breadth; but more particularly without change of depth, by a supposed decrease of information. *Descent*, for a decrease of breadth and increase of depth, without change of information.

Let us next consider the effect of the different kinds of reasoning upon the breadth, depth, and area of the two terms of the conclusion.

In the case of deductive reasoning it would be easy to show, were it necessary, that there is only an increase of the extensive distinctness of the major, and of the comprehensive distinctness of the minor, without any change in information. Of course, when the conclusion is negative or particular, even this may not be effected.

Induction requires more attention. Let us take the following example: —

S', S'', S''', and S^{IV} have been taken at random from among the M's;

S' S'', S''', and S^{IV} are P:

$\therefore$ any M is P.

We have here, usually, an increase of information. M receives an increase of depth, P of breadth. There is, however, a difference between these two increases. A new predicate is actually added to M; one which may, it is true, have been covertly predicated of it before, but which is now actually brought to light. On the other hand, P is not *yet* found to apply to anything but S', S'', S''', and S^{IV}, but only to apply to whatever else may hereafter be found to be contained under M. The induction itself does not make known any such thing. Now take the following example of hypothesis: —

M is, for instance, P', P'', P''', and P^{IV};

S is P', P'', P''', and P^{IV}:

$\therefore$ S is all that M is.

Here again there is an increase of information, if we suppose the premises to represent the state of information before the inferences. S receives an addition to its depth; but only a potential one, since there is nothing to show that the M's have any common characters besides P', P'', P''', and P^{IV}. M, on the other hand, receives an actual increase of breadth in S, although, perhaps, only a *doubtful* one. There is, therefore, this important difference between induction and hypothesis, that the former potentially increases the breadth of one term, and actually increases the depth of another, while the latter potentially in-

creases the depth of one term, and actually increases the breadth of another.

Let us now consider reasoning from definition to definitum, and also the argument from enumeration. A defining proposition has a meaning. It is not, therefore, a merely identical proposition, but there is a difference between the definition and the definitum. According to the received doctrine, this difference consists wholly in the fact that the definition is distinct, while the definitum is confused. But I think that there is another difference. The definitum implies the character of being designated by a word, while the definition, previously to the formation of the word, does not. Thus, the definitum exceeds the definition in depth, although only *verbally*. In the same way, any unanalyzed notion carries with it a feeling, — a constitutional word, — which its analysis does not. If this be so, the definition is the predicate and the definitum the subject, of the defining proposition, and this last cannot be simply converted. In fact, the defining proposition affirms that whatever a certain name is applied to is supposed to have such and such characters; but it does not strictly follow from this, that whatever has such and such characters is actually called by that name, although it certainly *might* be so called. Hence, in reasoning from definition to definitum, there is a verbal increase of depth, and an actual increase of extensive distinctness (which is analogous to breadth). The increase of depth being merely verbal, there is no possibility of error in this procedure. Nevertheless, it seems to me proper, rather to consider this argument as a special modification of hypothesis than as a deduction, such as is reasoning from definitum to definition. A similar line of thought would show that, in the argument from enumeration, there is a verbal increase of breadth, and an actual increase of depth, or rather of comprehensive distinctness, and that therefore it is proper to consider this (as most logicians have done) as a kind of infallible induction. These species of hypothesis and induction are, in fact, merely hypotheses and inductions from the essential parts to the essential whole; this sort of reasoning from parts to whole being demonstrative. On the other hand, reasoning from the substantial parts to the substantial whole is not even a probable argument. No ultimate part of matter fills space, but it does not follow that no matter fills space.

Five hundred and eighty-eighth Meeting.

December 10, 1867. — ADJOURNED STATUTE MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary read letters relative to exchanges; also a letter from Professor C. H. F. Peters, in acknowledgment of his election as an Associate Fellow of the Academy; and a letter from Henry S. Maine, in acknowledgment of his election as a Foreign Honorary Member.

The President called the attention of the Academy to the recent decease of Professor Bopp, of the Foreign Honorary Members.

On the motion of Dr. E. H. Clark, a committee was appointed to urge upon Congress the adoption of the decimal systems of weights and measures. Dr. E. H. Clark, Professor F. H. Storer, and Professor Horsford were appointed on this committee.

Professor F. H. Storer, the Librarian, moved that a committee be appointed to consider and report upon the meaning of the statutes which relate to the powers and duties of the Librarian and the Library Committee. In accordance with this motion the following committee was appointed: Professor Rogers, Mr. J. I. Bowditch, and Mr. O. Pickering.

Mr. Roland G. Hazard, of Peace Dale, Rhode Island, was elected an Associate Fellow in Class III., Section 1.

Five hundred and eighty-ninth Meeting.

January 14, 1868. — MONTHLY MEETING.

The CORRESPONDING SECRETARY in the chair.

The Corresponding Secretary announced the recent decease of Mr. Charles C. Jewett, of the Resident Fellows; of Rev. Chester Dewey, of Rochester, N. Y., of the Associate Fellows; and of M. Rayer, of Paris, of the Foreign Honorary Members.

Dr. C. T. Jackson exhibited to the Academy a series of lead-encased block-tin tubes or pipes for the conduction of

water, manufactured by the Boston Lead Company, Shaw and Willard's patent.

"The first lot was made by placing two semicylinders of pure block-tin around a hollow core, or mandril, through which a current of cold water could be made to run, so as to keep the tin as cool as possible. The semicylinders of tin were also chilled in snow or pounded ice. When placed around the core, and held closely together by tongs, melted lead, at as low a temperature as it could be cast, was poured around the tin, and allowed to cool, the compound cylinder being eight inches long and six inches in diameter. Then, by means of a powerful hydraulic press, giving a pressure of 3,150 pounds per square inch, or between four and five hundred tons upon the ram or piston, the cylinder of lead and tin was forced out below, a mandril, or former, keeping the inner portion of the tube open and of a uniform size. When the thick cylinder was nearly driven out of its mould, the press was stopped, and a new casting was made upon the remaining metal; so that continuous and perfectly united tubes of any desired length were formed, and were wound up on a reel in a room below. By this method, it was thought, a pipe lined with pure block-tin surrounded by the more flexible lead could be produced; but it has been found that pipes made in this way charged the water which stood in them over-night with lead.

"Dr. Jackson was therefore called upon to make a series of analyses of the linings of many of these tubes, and discovered that the lining was composed of 22 per cent of lead and 88 per cent of tin, or an alloy. He was then invited to witness the operation of making the pipes, when every endeavor to prevent the penetration of the molten lead into the substance of the tin proved that it was impossible, so long as the molten lead was cast around the tin, — for the lead requires a temperature of 612° for its fusion, and tin only 442°; while the great mass of hot lead rendered the tin almost a paste, into which the lead readily penetrated. There being 170° difference between the melting-points of the two metals, it was suggested that, if the lead was cast first around an iron core, and, when cold enough, on withdrawing the core and casting in the tin, the difficulty might be remedied. This, the foreman of the works said, could be easily effected, and it was soon after done with entire success; for chemical analysis showed the tin lining of such pipes to be absolutely pure tin. By this improved pro-

cess all the pipes now made at the Boston lead-works, and also at the New York works, are manufactured; and the public may rely on their producing a faultless water-pipe.

"It is also found that, by this improvement, the pipes can be made more rapidly than heretofore, and that a plug or compound cylinder for drawing may be cast thirteen inches long, which is a great advantage.

"A series of experiments were made to ascertain the action of distilled water and of Boston well-water on lead pipes, and on those made as first described, in which the tin had become alloyed with 22 per cent of lead; and it was found that a lead pipe in 24 hours yielded to distilled water 4·80 grs. of oxide of lead per gallon, and that a pipe lined with tin alloyed with 22 per cent of lead yielded to a gallon of the water 2·24 grs. of oxide of lead, while the pipe lined with pure tin yielded nothing to the water. When Boston well-water, containing 26 grs. of various saline matters per gallon, was substituted for distilled water, lead pipe, in 24 hours, yielded to it 2 grains of oxide of lead, and the pipe lined with tin alloyed with 22 per cent of lead yielded 1·865 grs. of lead to the water, the sulphates in the well-water protecting the lead to a considerable extent. The well-water of Waltham, which was very much less saline than Boston well-water, dissolved 0·8 gr. of oxide of lead from a pipe made of the tin alloyed with lead; this impregnation having taken place in a single night, or about 12 hours.

"It would seem from these researches, that the lead-encased tin pipe, as originally manufactured, is better than lead pipe, but is still objectionable as a water conduit, and much more so for more powerful solvents for lead, such as soda-water and beer; while the pipe, as now made, is as unobjectionable as pure block-tin pipe, and is actually cheaper than lead when purchased by the linear foot."

Five hundred and ninetieth Meeting.

January 29, 1868. — STATUTE MEETING.

The PRESIDENT in the chair.

Professor August De La Rive was elected a Foreign Honorary Member in Class I. Section 3, in place of the late Michael Faraday.

Professor M. E. Chevreul was also elected a Foreign Honorary Member in Class I. Section 3.

Five hundred and ninety-first Meeting.

February 11, 1868. — MONTHLY MEETING.

The PRESIDENT in the chair.

The following paper was presented and read by the author: —

A Conjectural Solution of the Origin of the Classificatory System of Relationship.

By LEWIS H. MORGAN,

OF ROCHESTER, NEW YORK.

ABOUT twenty years ago I found among the Iroquois Indians of New York a system of relationship, for the designation and classification of kindred, both unique and extraordinary in its character, and wholly unlike any with which we are familiar. At the time I supposed it was a scheme devised by themselves, and confined to this particular stock of the American aborigines. Afterwards, in 1857, I had occasion to re-examine the subject, when the idea of its possible prevalence among other Indian nations suggested itself, together with its uses, in that event, for ethnological purposes. In the following summer I obtained the system of the Ojibwa Indians, of Lake Superior; and, although prepared in some measure for the result, it was with some degree of surprise that I found among them the same elaborate and complicated system which then existed among the Iroquois. Every term of relationship was radically different from the corresponding term in the Iroquois; but the classification of kindred was the same. It was manifest that the two systems were identical in their radical characteristics. It seemed probable, also, that both were derived from a common source, since it was not supposable that two peoples, although speaking dialects of stock-languages, as widely separated as the Algonkin and Iroquois, could simultaneously have invented the same system, or derived it by borrowing one from the other.

From this fact of identity, several inferences at once presented

themselves. Its prevalence among these stocks rendered probable its prevalence among the remaining stocks of the American aborigines. If then it should, upon investigation, be found to be universal among them, it would follow that the system was coeval, in point of time, with the commencement of their spread upon the American continent; and also, as a system transmitted with the blood, it might contain the necessary evidence to establish their unity of origin. And, in the next place, if the Indian family came in fact from Asia, that they must have brought the system with them from that continent, and have left it behind them among the people from whom they separated; and, further than this, that its perpetuation upon this continent would render probable its like perpetuation upon the Asiatic, where it might still be found; and, finally, that it might possibly furnish some evidence upon the question of the Asiatic origin of the Indian family.

Having found, before the close of 1859, that the system prevailed in the five principal Indian stock-languages east of the Rocky Mountains, as well as in several of the dialects of each, its universal spread through the Indian family had become extremely probable; and having also discovered traces of it both in the Sandwich Islands and in South-India, it seemed advisable to prosecute the investigation upon a more extended scale, and to attempt to reach, as far as possible, all the families of mankind. This would require an extensive foreign correspondence, which a private individual could not hope to maintain successfully. I then applied to the Secretaries of the several American Boards of Foreign Missions for the co-operation of their respective missionaries in foreign fields, which was cordially promised, and the promise amply redeemed. I also applied to Professor Joseph Henry, Secretary of the Smithsonian Institution, for the use of the name of that institution to insure attention to the circular and schedule by means of which the system of relationship of the different nations was to be obtained. Professor Henry not only complied with this request, but also, at my suggestion, procured a circular to be issued by the Secretary of State of the United States to the diplomatic and consular representatives of the government in foreign countries, commending the investigation to their attention. From this time onward, the foreign correspondence, except with the missionaries, was conducted through the Smithsonian Institution and the Department of State.

In verification of the results it will be sufficient to state, that, by personal explorations, continued through several years, in the Lake

Superior region, in the Hudson's Bay Territory, and in the territories between the Missouri River and the Rocky Mountains, and by correspondence with government officials and private individuals in other parts of North America, I have been able to bring together the system of relationship of upwards of seventy Indian nations, speaking as many independent dialects. Beside these, and by means of the foreign correspondence referred to, the system of the principal nations of Europe and Asia, of a portion of those of Africa, of Central and South America, and of the Islands of the Pacific, have also been obtained. The tabulated schedules, now in course of publication by the Smithsonian Institution, will cover four hundred and fifty pages of the Smithsonian Contributions, and represent four fifths and upwards, numerically, of the entire human family. These strictly personal statements would be inappropriate in this connection, except as they become necessary to show that the *solution* about to be presented rests upon a wide basis of ascertained facts.

I propose to present, in a brief form, 1st. The system of relationship of the Aryan Family: using the Roman form as typical. 2d. That of the Malayan Family: using the Hawaiian form as typical. 3d. That of the Ganowanian* Family: using the Seneca-Iroquois as typical. These are preliminary to the principal object, which is: 4th. To submit *a conjectural solution of the origin of the classificatory system of relationship.*

It may be premised that all of the systems of consanguinity and affinity, thus far ascertained, resolve themselves into two radically distinct forms, of which one will be called the *descriptive*, and the other the *classificatory.*

In the first, consanguinei are, in the main, described by a combination of the primary terms of relationship. There is a small amount of classification, by means of special or secondary terms introduced by civilians and scholars to relieve the burdensomeness of the system; but the great body of relatives, both by blood and marriage, are described. This is the system of the Aryan, Semitic, and Uralian families. In its origin, as the parent of the present form, it was purely descriptive, as is still exemplified by the Erse and Scandinavian, and by the condition of the Sanskritic, when this language ceased to be spoken. This system follows the streams of the blood, and is in

* Gä-no-wä′-ni-an: name proposed for the American Indian family. From Gä′-no, an arrow, and Wä-ä′-no, a bow; the family of the Bow and Arrow.

accordance with the nature of descents. It is, therefore, a natural system, for the reason that the relationships recognized are those which actually exist. But it assumes as its fundamental basis the antecedent existence of *marriage between single pairs.* Before this system could come into existence, mankind must have raised themselves to this state of marriage; after which this form of marriage, and not nature, teaches the descriptive system of relationship. It is important that this distinction should be noted.

In the second form, consanguinei are never described by a combination of the primary terms; but they are classified into categories, and the same term of relationship is applied, without distinction, to each of the members of the same category. This is the system of the Malayan, Ganowanian, and Turanian families. It suggests the probability that there might have been a state of society in the primitive ages in which marriage between single pairs was unknown, in which the family, in its modern sense, was unknown; but in which a system of relationship might have originated in *compound marriages in a communal family,* and thus be in strict accordance with the nature of descents, and, therefore a natural system because it recognized the relationships actually existing. This suggestion should also be noted.

1. *System of Relationship of the Aryan Family.*

A knowledge of the descriptive system became important for two principal reasons. First, it was necessary to find the limits of its spread to circumscribe the classificatory form: and, secondly, it was necessary to find the basis upon which it rested, to reach the instrumentalities by means of which the classificatory system, if it ever prevailed among the remote ancestors of the Aryan family, might possibly have been overthrown, and the descriptive substituted in its place.

As none of the characteristics of the former system are involved in the solution of the origin of the latter, it will be sufficient for my present purpose to present the substance of the Aryan form without comment. The Roman, as found in the Pandects* and Institutes of Justinian,† will be used as the typical system. Its completeness and perfection is due to the Roman civilians, and arose from a necessity for a code of descents, defining the relations of consanguinei to each other, to regulate the transmission of property by inheritance.

* Pand. Lib. XXXVIII. Tit. X. "De gradibus et adfinibus et nominibus eorum."

† Just. Inst. Lib. III. Tit. VI. "De gradibus Cognationum."

Table of Roman System of Consanguinity.

(Lineal Line.)

Great-grandfather's great-grandfather,	Tritavus.
“ “ grandfather,	Atavus.
“ “ father,	Abavus.
“ grandfather,	Proavus.
“ grandmother,	Proavia.
Grandfather,	Avus.
Grandmother,	Avia.
Father,	Pater.
Mother,	Mater.
Son,	Filius.
Daughter,	Filia.
Grandson,	Nepos.
Granddaughter,	Neptis.
Great-grandson,	Pronepos.
“ granddaughter,	Proneptis.
“ grandson's son,	Abnepos.
“ “ daughter,	Abneptis.
“ “ grandson,	Atnepos.
“ “ granddaughter,	Atneptis.
“ “ great-grandson,	Trinepos.
“ “ “ granddaughter,	Trineptis.

(First Collateral Line. Male.)

Brother,	Frater.
Brother's son,	Fratris filius.
“ daughter,	“ filia.
“ grandson,	“ nepos.
“ granddaughter,	“ neptis.
“ great-grandson,	“ pronepos.
“ “ granddaughter,	“ proneptis.
* * *	* * *

(First Collateral Line. Female.)

Sister,	Soror.
Sister's son,	Sororis filius.
“ daughter,	“ filia.
“ grandson,	“ nepos.
“ granddaughter,	“ neptis.
“ great-grandson,	“ pronepos.
“ “ granddaughter,	“ proneptis.
* * *	* * *

(Second Collateral Line. Father's Side.)

MALE BRANCH.

Father's brother,	Patruus.
“ brother's son,	Patrui filius, b. frater patruelis.
“ “ daughter,	“ filia, b. soror patruelis.
“ “ grandson,	“ nepos.
“ “ granddaughter,	“ neptis.
“ “ great-grandson,	“ pronepos.
“ “ “ granddaughter,	“ proneptis.
* * *	* * *

FEMALE BRANCH.

Father's sister,	Amita.
“ sister's son,	Amitæ, filius b. amitinus.
“ “ daughter,	“ filia, b. amitina.
“ “ grandson,	“ nepos.
“ “ granddaughter,	“ neptis.
“ “ great-grandson,	“ pronepos.
“ “ “ granddaughter,	“ proneptis.
* * *	* * *

(*Second Collateral Line. Mother's Side.*)

MALE BRANCH.

Mother's brother,	Avunculus.
" brother's son,	Avunculi filius, b. consobrinus.
" " daughter,	" filia, b. consobrina.
" " grandson,	" nepos.
" " granddaughter,	" neptis.
" " great-grandson,	" pronepos.
" " " granddaughter,	" proneptis.
* * *	* * *

FEMALE BRANCH.

Mother's sister,	Matertera.
" sister's son,	Materteræ filius, b. consobrinus.
" " daughter,	" filia, b. consobrina.
" " grandson,	" nepos.
" " granddaughter,	" neptis.
" " great-grandson,	" pronepos.
" " " granddaughter,	" proneptis.
* * *	* * *

(*Third Collateral Line. Father's Side.*)

MALE AND FEMALE BRANCH.

Father's father's brother,	Patruus magnus.
" " brother's son,	Patrui magni filius.
" " " daughter,	" " filia.
" " " grandson,	" " nepos.
" " " granddaughter,	" " neptis.
" " " great-grandson,	" " pronepos.
" " " " granddaughter,	" " proneptis.
* * *	* * *
" " sister,	Amita magna.
" " sister's son,	Amitæ magnæ filius.
" " " daughter,	" " filia.
" " " grandson,	" " nepos.
" " " granddaughter,	" " neptis.
" " " great-grandson,	" " pronepos.
" " " " granddaughter,	" " proneptis.
* * *	* * *

(*Third Collateral Line. Mother's Side.*)

MALE AND FEMALE BRANCH.

Mother's mother's brother,	Avunculus magnus.
" " brother's son,	Avunculi magni filius.
" " " daughter,	" " filia.
" " " grandson,	" " nepos.
" " " granddaughter,	" " neptis.
" " " great-grandson,	" " pronepos.
" " " " gr'ddaughter,	" " proneptis.
* * *	* * *
" " sister,	Matertera magna.
" " sister's son,	Materteræ magnæ filius.
" " " daughter,	" " filia.
" " " grandson,	" " nepos.
" " " granddaughter,	" " neptis.
" " " great-grandson,	" " pronepos.
" " " " granddaughter,	" " proneptis.
* * *	* * *

(Fourth Collateral Line. Father's Side.)

MALE AND FEMALE BRANCH.

Father's father's father's brother,	Patruus major,
" " " brother's son,	Patrui majoris filius.
" " " " grandson,	" " nepos.
" " " " g't-grandson,	" " pronepos.
* * *	* * *
" " " sister,	Amita major.
" " " sister's son,	Amitæ majoris filius.
" " " " grandson,	" " nepos.
" " " " great-grandson,	" " pronepos.
* * *	* * *

(Fourth Collateral Line. Mother's Side.)

MALE AND FEMALE BRANCH.

Mother's mother's mother's brother,	Avunculus major.
" " " brother's son,	Avunculi majoris filius.
" " " " grandson,	" " nepos.
" " " " g't-g'dson,	" " pronepos.
* * *	* * *
" " " sister,	Matertera major.
" " " sister's son,	Materteræ majoris filius.
" " " " grandson,	" " nepos.
" " " " g't-gr'dson,	" " pronepos.
* * *	* * *

(Fifth Collateral Line. Father's Side.)

MALE AND FEMALE BRANCH.

Father's father's father's father's brother,*	Patruus maximus.
" " " " bro's son,	Patrui maximi filius.
" " " " " grandson,	" " nepos.
" " " " " g't-g'dson,	" " pronepos.
* * *	* * *
" " " " sister,	Amita maxima.
" " " " sister's son,	Amitæ maximæ filius.
" " " " " g'dson,	" " nepos.
" " " " " g't-g'dson,	" " pronepos.
* * *	* * *

(Fifth Collateral Line. Mother's Side.)

MALE AND FEMALE BRANCH.

Mother's mother's mr's m'r's brother,	Avunculus maximus.
" " " " bro's son,	Avunculi maximi filius.
" " " " " grandson,	" " nepos.
" " " " " g't-grandson,	" " pronepos.
* * *	* * *
" " " " sister,	Matertera maxima.
" " " " sister's son,	Materteræ maximæ filius.
" " " " " grandson,	" " nepos.
" " " " " g't-g'dson,	" " pronepos.
* * *	* * *

(Marriage Relations.)

Husband,	Vir. b. maritus.
Husband's father,	Socer.
" mother,	Socrus.
" grandfather,	Socer magnus.
" grandmother,	Socrus magna.
Wife,	Uxor. b. marita.

Wife's father,	Socer.
" mother,	Socrus.
" grandfather,	Socer magnus.
" grandmother,	Socrus magna.
Step-father,	Vitricus.
" mother,	Noverca.
" son,	Privignus.
" daughter,	Privigna.
Son-in-law,	Gener.
Daughter-in-law,	Nurus.
Brother-in-law (husband's brother),	Levir.
" " (sister's husband),	Maritus sororis.
" " (wife's brother),	Uxoris frater.
Sister-in-law (wife's sister),	Uxoris soror.
" " (husband's sister),	Gloss.
" " (brother's wife),	Fratria.
Relatives by father's side,	Agnati.
" " mother's side,	Cognati.
" " marriage,	Affines.

Each collateral line, when fully extended, reaches to "trinepos," who is the sixth descendant in each line. If desirable to trace the line beyond him, he is made a new starting-point in the description, namely, "*fratris trinepotis filius*," and on to "*fratris trinepotis trinepos*," who is the twelfth descendant of my brother. In like manner, in the ascending series, "*tritavus*" becomes a new starting-point, which gives first "*tritavi pater*," the father of *tritavus*, and on to *tritavi tritavus*, who is the twelfth ancestor of *Ego*. This exhausts the capacity of the nomenclature of this admirable system.

It will be observed that consanguinei are bound together in virtue of their descent, through married pairs, from common ancestors; that they are divided into a lineal and several collateral lines; and that the collateral are perpetually divergent from the lineal. The relationship of each person to the central *Ego* is accurately defined, and preserved distinct by means of a descriptive phrase. With the exception of the primary terms of relationship, which are those for father and mother, son and daughter, brother and sister, grandparent and grandchild, and husband and wife; and with the further exception of the terms for uncle and aunt which are found in the Sanskritic, Hellenic, Romaic, Germanic, and Slavonic stock-languages; and also with the exception of *nepos* and its cognates, which has an eccentric use,— the remainder of the system describes persons, leaving the relationship to implication. As before stated, the system, in its immediate origin, was purely descriptive. The Erse and Gaelic, which have no terms for uncle, aunt, nephew, niece, or cousin, is more strictly than the Roman the typical system of the Aryan family. This system will be dismissed without further

explanation, as the table will sufficiently illustrate the fundamental differences between this form and the classificatory which is next to be presented.

II. *System of Relationship of the Malayan Family.*

The Malayan is nearer the primitive system of relationship of the human family than any other hitherto discovered. This is a necessary inference from the fact that it is simpler, and therefore older, than the Ganowanian and Turanian systems, which prevail among the great body of the American Indian and Asiatic nations. It is also evident that the Malayan could not have been derived from either of the other forms, whilst both the Ganowanian and Turanian might have been, and presumptively were, engrafted upon an original form agreeing in all essential respects with the Malayan. It is a classificatory system as well as the most simple and elementary form of that system. The only relationships recognized are the primary. All consanguinei, near and remote, are classified under these relationships. Each term is in common gender; sex being indicated by adding the words *Kă'-na* for male, and *Wä-hee'-na* for female. A full knowledge of the system may be obtained by passing through the several lines, and observing the relationship of each person to the central *Ego.*

In the lineal line we have *Kŭ-pŭ'-na*, grandparent, *Ma-kŭ'-a*, parent, *Kai'-kee*, child, and *Mŭ-pŭ'-na*, grandchild. The relationship of brother and sister is conceived in the twofold form of elder and younger; and there are double terms for each relationship, one of which is used by the males and the other by the females, as follows: —

Elder brother, male speaking,	*Kai-kŭ-ä-ä'-na.*	Female speaking,	*Kai-kŭ-nä'-ne.*
Younger " " "	*Kai-ka-i'-na.*	" "	*Kai-kŭ-nä'-ne.*
Elder sister, " "	*Kai-kŭ-nä-he'-ne.*	" "	*Kai-kŭ-ä-ä'-na.*
Younger sister, " "	*Kai-kŭ-wa-he'-ne.*	" "	*Kai-ka-i'-na.*

For husband and wife the terms are respectively, *Kä'-na,* and *Wä-hee'-na.*

In the first collateral line, my brother's son and daughter are my son and daughter, each of them calling me father; and their children are my grandchildren, each of them calling me grandfather. My sister's children are also my sons and daughters, and their children are my grandchildren. The same is equally true whether I am a male or a female.

In the second collateral line, my father's brother is my father; his son and daughter are my brother and sister, elder or younger, and I

apply to them the same terms I do to my own brothers and sisters; the children of this collateral brother and sister are my sons and daughters; and the children of the latter are my grandchildren. Each of the persons named applies to me the proper correlative.

My father's sister, in like manner, is my mother; her children are my brothers and sisters, elder or younger; the children of these collateral brothers and sisters are my sons and daughters; and the children of the latter are my grandchildren.

My mother's brother is my father; and his children and descendants follow in the same relationships as in the previous cases. In like manner my mother's sister is my mother; and her children and descendants follow in the same relationships.

The third collateral line repeats the classification in the second. My grandfather's brother is my grandparent; his son is my father; the son of the latter is my brother, elder or younger; and the son and grandson of this collateral brother are my child and grandchild. My grandfather's sister and her descendants, and my grandmother's brother and sister and their descendants, follow in the same relationships as before. As far outward as consanguinei can be traced, the classification is the same. It will be seen more fully by consulting the following table.

HAWAIIAN SYSTEM OF RELATIONSHIP.

VOWEL SOUNDS.

ä, as in art; ă, as in at; ĕ, as in met; ĭ, as in it; ŏ, as in got; ŭ, as oo in food. Kŭ-ŭ = my.

DESCRIPTION OF PERSONS.	RELATIONSHIP IN HAWAIIAN.	SAME IN ENGLISH.
My great-grandfather	Kŭ-ŭ kŭ-pŭ′-na	My grandparent.
" " grandfather's brother	" "	" "
" " " sister	" "	" "
" " grandmother	" "	" "
" " grandmother's brother	" "	" "
" " " sister	" "	" "
" grandfather	" "	" "
" grandfather's brother	" "	" "
" " sister	" "	" "
" grandmother	" "	" "
" grandmother's brother	" "	" "
" " sister	" "	" "
" father	" mä-kŭ′-ă kä′-na	" parent, male.
" mother	" " wä-hee′-na	" " female.
" son	" käi′-kee kä′-na	" child, male.
" daughter	" " wä-hee′-na	" " female.
" grandson	" moo-pŭ′-nă kä′-na	" grandchild, male.
" granddaughter	" " wä-hee′-na	" " female.
" great-grandson	" " kä′-na	" " male.
" " granddaughter	" " wä-hee′-na	" " female.
" " great-grandson	" " kä′-na	" " male.
" great-great-granddaughter	" moo-pŭ′-nă wä′-hee′-na	My grandchild, female.
" older brother (*male speaking*)	" käi-kŭ-ä-ä′-na	" brother, older.
" " " (*female* ")	" käi-ku-nă′-ne	" " "
" " sister (*male* ")	" käi-kŭ-wä-hee′-na	" sister, "
" " " (*female* ")	" käi-kŭ-ä′-ä′-nä	" " "
" younger brother (*male* ")	" käi′-käi-na	" brother, younger.

My younger brother (*female* ")	Kŭ-ŭ käi-kŭ-nä'-në	My brother, younger.
" " sister (*male* ")	" käi-kŭ-nä-he'-na	" sister, "
" " " (*female* ")	" käi-ka-i'-na	" " "
" (a man's) brother's son	" käi'-kee kä'-na	" child, male.
" " " son's wife,	" hŭ-no'-nă	" daughter-in-law.
" " " daughter	" käi'-kee wä-hee'-na	" child, female.
" " " daughter's husband	" hŭ-no'-nă	" son-in-law.
" " " grandson	" moo-pŭ'-nă kä'-na	" grandchild, male.
" " " granddaughter	" " wä-hee'-na	" " female.
" " " great-grandson	" " kä'-na	" " male.
" " " " granddaughter	" " wä-hee'-na	" " female.
" " sister's son	" käi'-kee kä'-na	" child, male.
" " " son's wife	" hŭ-no'-nă	" daughter-in-law.
" " " daughter	" käi'-kee wä-hee'-na	" child, female.
" " " daughter's husband	" hŭ-no'-nă	" son-in-law.
" " " grandson	" moo-pŭ'-na kä'-na	" grandchild, male.
" " " granddaughter	" " wä-hee'-na	" " female.
" " " great-grandson	" " kä'-na	" " male.
" " " " granddaughter	" " wä-hee'-na	" " female.
" (a woman's) sister's son	" käi'-kee kä'-na	" child, male.
" " " son's wife	" hŭ-no'-nă	" daughter-in-law.
" " " daughter	" käi'-kee wä-hee'-na	" child, female.
" " " daughter's husband	" hŭ-no'-nă	" son-in-law.
" " " grandson	" moo-pŭ'-na kä'-na	" grandchild, male.
" " " granddaughter	" " wä-hee'-na	" " female.
" " " great-grandson	" " kä'-na	" " male.
" " sister's great-granddaughter	" moo-pŭ'-na wä-hee'na	" " female.
" " brother's son	" käi'-kee kä'na	" child, male.
" " " son's wife	" hŭ-no'-nă	" son-in-law.
" " " daughter	" käi'-kee wä-hee'-na	" child, female.
" " " daughter's husband	" hŭ-no'-nă	" son-in-law.
" " " grandson	" moo-pŭ'-na kä'-na	" grandchild, male.

DESCRIPTION OF PERSONS.	RELATIONSHIP IN HAWAIIAN.	[illegible]
My (a woman's) brother's granddaughter	Kŭ-ŭ moo-pŭ′-nă wä-hee′-na	" " female.
" " " great-grandson	" " kä′-na	" " male.
" " " " granddaughter	" " wä-hee′-na	" " female.
" father's brother	" mä-kŭ′-ă kä′-na	" parent, male.
" " brother's wife	" " wä-hee′-na	" " female.
" " sister	" " "	" " "
" " sister's husband	" " kä′-na	" " male.
" mother's brother	" " "	" " "
" " brother's wife	" " wä-hee′-na	" " female.
" " sister	" " "	" " "
" " sister's husband	" " kä′-na	" " male.
" father's brother	" " "	" " "
" " brother's son (*male speaking*)	" käi-kŭ-ä-ä′-na (older) kai-kai′-na (y.)	" brother.
" " " son's wife	" wä-hee′na	" wife or my female.
" " " daughter	" käi-kŭ wä-hee′-na	" sister.
" " " daughter's husband	" käi′-ko ee′-ka	" brother-in-law.
" " " son's son	" käi-kee kä-na	" child, male.
" " " " daughter	" käi-kee wä-hee′-na	" " female.
" " " daughter's son	" käi′-kee kä′-na	" " male.
" " " " daughter	" käi′-kee wä-hee′-na	" " female.
" " " great-grandson	" moo-pŭ′-na kä′-na	" grandchild, male.
" " " " granddaughter	" " wă-hee′-na	" " female.
" " " " great-grandson	" " kä′-na	" " male.
" " " " " granddaughter	" " wä-hee′-na	" " female.
" " sister	" mä-kŭ′-ă wä-hee′-na	" parent, male.
" " sister's son	" käi-kŭ-ä-ä′-na (o.) kai′-kai-na (y.)	My brother.
" " " son's wife	" wä-hee′na	" wife or my female.
" " " daughter	" käi-kŭ wä-hee′-na	" sister.
" " " daughter's husband	" käi-ko-ee′-ka	" brother-in-law.
" " " son's son	" kai-kee kä′-na	" child, male.
" " " " daughter	" käi-kee wä-hee′na	" " female.
" " " daughter's son	" kai′-kee kä′-na	" " male.

My father's sister's daughter's daughter	Kŭ-ŭ " wä-hee'na	My child female.
" " " great-grandson	" moo-pŭ-na kä-na	" grandchild, male.
" " " " granddaughter	" " wä-hee'-na	" " female.
" " " " great-grandson	" " kä'-na	" " male.
" " " " " granddaughter	" " wä-hee'-na	" " female.
" mother's sister	" mä-kŭ-ä-kä'-na	" parent, female.
" " sister's son	" käi-ku-a-ä'-ne (o.) käi-kai'-na (y.)	" brother.
" " " son's wife	" wä-hee'-na	" wife or my female.
" " " daughter	" käi-kŭ wä hee'-na	" sister.
" " " daughter's husband	" käi-ko-ee'-ka	" brother-in-law.
" " " son's son	" kai'-kee kä'-na	" child, male.
" " " " daughter	" " wä-hee'-na	" " female.
" " " daughter's son	" " kä'-na	" " male.
" " " " daughter	" " wä-hee'-na	" " female.
" " " great-grandson	" moo-pŭ'-na kä'-na	" grandchild, male.
" " " " granddaughter	" " wä-hee'-na	" " female.
" " " " great-grandson	" " kä'-na	" " male.
" " " " " granddaughter	" " wä-hee-na	" " female.
" " brother	" mä-kŭ-a kä'-na	" parent, male.
" " brother's son	" kăi-kŭ-ä-ä'-na (o.) käi-käi-na (y.)	" brother.
" " " son's wife	" wä-hee'-na	" wife or my female.
" " " daughter	" käi'-kŭ wa-hee'-na	" sister.
" " " daughter's husband	" käi-ko-ee'-ka	" brother-in-law.
" " " son's son	" käi'-kee kä'-na	" child, male.
" " " " daughter	" " wä-hee'-na	" " female.
" " brother's daughter's son	" käi'-kee-kä'-na	" child, male.
" " " " daughter	" " wä-hee'na	" " female.
" " " great-grandson	" moo-pŭ'-nä kä'na	" grandchild, male.
" " " " granddaughter	" " wä-hee'-na	" " female.
" " " " great-grandson	" " kä'-na	" " male.
" " " " " granddaughter	" " wä-hee'na	" " female.
" father's father's brother's son	" mä-kŭ-ă kä'-na	" parent, male.
" " " " daughter	" " wä-hee'-na	" " female.

DESCRIPTION OF PERSONS.	RELATIONSHIP IN HAWAIIAN.	SAME IN ENGLISH.
My father's father's brother's son's son	Kŭ-ŭ käi-kŭ-ä-ä′-na (o.) käi-käi′-na (y.)	My brother.
" " " " " daughter	" käi-kŭ-ä-hee′-na	" sister.
" " " " daughter's son	" käi-kŭ-ä-ä-na (o.) käi-käi′-na (y.)	" brother.
" " " " " daughter	" käi-kŭ-ä-hee′-na	" sister.
" " " " great-grandson	" kai-kee kä′-na	" child, male.
" " " " " granddaughter	" " wä-hee′-na	" " female.
" mother's mother's sister's son	" mä-kŭ′-ă kä′-na	" parent, male.
" " " " daughter	" " wä-hee′-na	" " female.
" " " " son's son	" käi-kŭ-ä-ä′-na (o.) käi-käi′-na (y.)	" brother.
" " " " " daughter	" käi-kŭ-ä-hee′-na	" sister.
" " " " daughter's son	" käi-kŭ-ä-ä′-na (o.) käi-käi′-na (y.)	" brother.
" " " " " daughter	" käi-kŭ-a-hee′-na	" sister.
" " " " great-grandson	" käi-kee-kä-na	" child, male.
" " " " " granddaughter	" " wä-hee′-na	" " female.
" husband	" kä′-na	" husband.
" wife	" wä-hee′-na	" wife.
" husband's father	" mä-kŭ-ä hŭ-nä-ai	" father-in-law.
" " mother	" " "	" mother-in-law.
" wife's father	" " "	" father-in-law.
" " mother	" " "	" mother-in-law.
" son-in-law	" hŭ-no′-nă kä′-na	" child-in-law, male.
" daughter-in-law	" " wä-hee′-na	" " " female.
" brother-in-law (husband's brother)	" kä′-na	" husband or my male.
" brother-in-law (sister's husband) (*female speaking*)	" kä′-na	" husband or my male.
" " " (wife's sister's husband)	" pŭ-nä-lŭ′-ä	" intimate companion.
" " " (wife's brother)	" käi-ko-a′-ka	" brother-in-law.
" sister-in-law (wife's sister)	" wa-hee′-na	" wife.
" " " (husband's sister)	" käi-ko-a′-ka	" sister-in-law.
" " " (brother's wife)	" wä-hee′-na	" wife.
" " " " " (*female speaking*)	" käi-ko-a′-ka	" sister-in-law.
" " " (husband's brother's wife)	" pŭ-na-lŭ-ä	" intimate companion.
" " " (wife's brother's wife)	" wa-hee′-na	" wife.

It will be observed that the several collateral lines are merged in the lineal line, by means of which the posterity of my brothers and sisters, and of my collateral relatives, become my posterity. This is a fundamental characteristic of the classificatory system. In the Hawaiian no blood relatives, however remote in degree, can fall without the relationship of grandparent, grandchild, brother, or sister. The system, nevertheless, is clearly defined, and is founded upon a knowledge of the degrees of relationship, numerically, by means of which the classification is perfected. When the Ganowanian and Turanian forms are compared with the Hawaiian, and the principles of each are understood, it will be seen that poverty of language has nothing whatever to do with the latter system. The relationships which seem to be unreal and arbitrary may be found, in the sequel, to be those actually existing when the system was formed.

In the Hawaiian there are five grades of relatives, as follows: Myself, my brothers and sisters, and my first, second, third, and more remote cousins, are the first grade. These are my brothers and sisters without distinction. My father and mother and their brothers and sisters, together with their several cousins, as before, are the second grade. These, without distinction, are my parents. My grandfather and his brothers and sisters, and my grandmother and her brothers and sisters, on the father's side and on the mother's side, together with their several cousins, as before, are the third grade. These are my grandparents. Below me, my sons and daughters and their several cousins are the fourth grade. These are my children. My grandsons and granddaughters, and their several cousins, are the fifth grade. These are my grandchildren.* The Hawaiian system now realizes the nine grades of relations of the Chinese (conceiving them reduced to five) more perfectly than the Chinese itself does at the present time. An ancient Chinese author remarks as follows: —

"All men born into the world have nine ranks of relatives. My own generation is one grade; my father's is one; my grandfather's is one; that of my grandfather's father is one; and that of my grandfather's grandfather is one; thus above me are four grades. My son's generation is one grade; my grandson's is one; that of my grandson's son is one; and that of my grandson's grandson is one; thus below me are four grades of relations: including myself in the estimate, there are in all nine grades. These are brethren; and although each grade be-

* All the individuals of the same grade are brothers and sisters to each other.

longs to a different house, or family, yet they are all my relatives, and these are called the nine grades of relations." A strong presumption arises from a comparison of the Hawaiian and Chinese systems, that the latter, in its original form, was identical, in all essential respects, with the former.

It remains to notice a remarkable custom of the Hawaiians, which had not entirely disappeared at the epoch of the establishment of the American missions. This custom was mentioned by Judge Lorin Andrews in explanation of a particular Hawaiian relationship in the following language: "The relationship of "*Pinalua*" is rather amphibious. It arose from the fact that two or more brothers, with their wives, and two or more sisters, with their husbands, were inclined to possess each other in common. But the modern use of the word is that of *dear friend*, or *intimate companion*." This custom has an intimate connection with the solution about to be presented.

III. *System of Relationship of the Ganowanian Family.*

The American Indians, when related, address each other by the term of relationship, and never by the personal name. As a custom it is substantially universal. If no relationship exists, the form of address is "my friend." This custom of saluting by kin has tended to impart as well as preserve a knowledge of the system, and to render it perfectly familiar to all. They recognize all the relationships known to the Aryan system, besides several which the latter does not discriminate. The system, as presented in the Table below, with some modifications in the different stock-languages, is now in practical daily use throughout the Ganowanian family.

In addition to a remarkably opulent nomenclature of relationships, some of these languages have a double set of terms for particular relationships, one of which is used by the males, and the other by the females. It will also be found, in very many cases, that the relationship of the same person to myself, a male, is different when I am a female. Notwithstanding the great diversities created by the system, it is logical and self-sustained throughout.

To develop its prominent characteristics it will be necessary to pass through the several lines, as in the former case.

The relationships of grandfather and grandmother, and of grandson and granddaughter, are the most remote which are recognized either in the ascending or descending series. Ancestors and descendants

above and below them fall into the same categories respectively. In the collateral lines persons of common descent cannot fall without the relationship of brother or cousin. The relationship of brother and sister is conceived in the twofold form of elder and younger, and not in the concrete; and there are special terms for each.

First Collateral Line.

With myself a male, my brother's son and daughter are my son and daughter, each of them calling me father. This is the first indicative feature of the system. My brother's grandchildren are my grandchildren, each of them calling me grandfather.

On the other hand, my sister's son and daughter are my nephew and niece, each of them calling me uncle. (Second indicative feature.) My sister's grandchildren are my grandchildren, each of them calling me grandfather.

With myself a female, the first relationships are reversed; my brother's son and daughter are my nephew and niece, each of them calling me aunt; whilst my sister's son and daughter are equally my son and daughter, each of them calling me mother. The children of these nephews and nieces, sons and daughters, are, without distinction, my grandchildren, each of them calling me grandmother. In each of the cases above named, as well as in those hereafter stated, the primary terms are used in their primary sense, *e. g.* I call my brother's son *my son*, when I speak to him, the same as though he were my own son.

Second Collateral Line.

My father's brother is my father, and calls me his son. (Third indicative feature.) His son and daughter are my brother and sister, elder or younger according to our respective ages. (Fourth indicative feature.) With myself a male, the children of this collateral brother are my sons and daughters, each of them calling me father; whilst the children of this collateral sister are my nephews and nieces, each of them calling me uncle. The children of each are my grandchildren, each of them calling me grandfather. On the contrary, with myself a female, the children of this collateral brother are my nephews and nieces, each of them calling me aunt; whilst the children of this collateral sister are my sons and daughters, each of them calling me mother. Their children in like manner are my grandchildren, each of them calling me grandmother.

My father's sister is my aunt. (Fifth indicative feature.) Her son and daughter are my cousins, each of them calling me cousin. With myself a male, the children of this male cousin are my sons and daughters, whilst the children of my female cousins are my nephews and nieces. On the contrary, with myself a female, the children of my male cousins are my nephews and nieces, whilst the children of my female cousins are my sons and daughters. The children of each of the latter are my grandchildren.

My mother's brother is my uncle. (Sixth indicative feature.) His son and daughter are my cousins, and their descendants follow in the same relationships respectively as in the last case.

My mother's sister is my mother. (Seventh indicative feature.) Her son and daughter are my brother and sister, elder or younger. (Eighth indicative feature.) The children and descendants of this collateral brother follow in the same relationships respectively as the descendants of my father's brother first above given.

Third Collateral Line.

This line is a counterpart in all respects of the first and second, with some additional relationships. My grandfather's brother is my grandfather. (Ninth indicative feature.) His son is my father; the son and daughter of this father are my brother and sister, elder or younger; the children of this collateral brother, myself a male, are my sons and daughters; of this collateral sister are my nephews and nieces, and their children are my grandchildren. With myself a female the same changes must be made as in the former cases.

My grandfather's sister is my grandmother; her daughter is my aunt; the children of this aunt are my cousins; and the children and descendants of the latter follow in the same relationships as before.

My grandmother's brother is my grandfather; his son is my uncle; the children of this uncle are my cousins; and the children and descendants of these cousins follow in the same relationships as before.

In like manner my grandmother's sister is my grandmother; her daughter is my mother; the children of this mother are my brothers and sisters, elder or younger; and the children and descendants of this collateral brother and sister follow in the same relationships as in previous cases.

The fourth and fifth collateral lines are counterparts of the first three, as will be found by consulting the subjoined Table.

In each of the foregoing the collateral lines are finally brought into and merged in the lineal line, which is a fundamental characteristic of the system. This also gives the tenth indicative feature. Certain relationships are here called "indicative," because they determine those which precede and follow them; and because they embrace so much which is radical and fundamental, that, when they are found present in different systems of relationship, the identity of these systems may be considered established.

The Seneca-Iroquois system of consanguinity and affinity, as given in the Table, now prevails, with modifications, in upwards of seventy Indian nations. Its radical characteristics are found in their several systems with such striking exactness as apparently to leave no doubt that it was derived into each stock-language with the blood from a common original source.

Another fact, not less significant, remains to be mentioned, namely, that the system of relationship of the people of South-India speaking the Drâvidian language, and numbering upwards of twenty-eight millions, is identical, with the exception of two or three unimportant particulars, with the Seneca-Iroquois. The same system, greatly modified by Sanskritic influence, also prevails among the people of North-India speaking the Gaura language, and numbering upwards of one hundred millions; and also, with further modifications, among the Chinese and Japanese.

For the purpose of comparison, and also for reference to the Asiatic form in the solution of the origin of the classificatory system, the Seneca-Iroqouis and the Tamil systems are placed side by side in the following Table.

Comparative Table of the System of Relationship of the Seneca-Iroquois Indians of New York, and of the People of South-India speaking the Tamil Dialect of the Drâvidian Language. En=my.

	Description of Persons.	Relationship in Seneca-Iroquois.	Translation.	Relationship in Tamil.	Translation.
1	My great-grandfather's father	hoc'-sote	My grandfather	En muppáddan	My 3d grandfather
2	" " " mother	oc'-sote	" grandmother	" muppáddi	" " grandmother
3	" great-grandfather	hoc'-sote	" grandfather	" pûddan	" 2d grandfather
4	" " grandmother	oc'-sote	" grandmother	" pûddi	" " grandmother
5	" grandfather	hoc'-sote	" grandfather	" päddăn	" grandfather
6	" grandmother	oc'-sote	" grandmother	" päddi	" grandmother
7	" father	hä'-nih	" father	" tákkäppăn	" father
8	" mother	no-yeh'	" mother	" táy	" mother
9	" son	hà-ah'-wuk	" son	" măkăn	" son
10	" daughter	ka-ah'-wuk	" daughter	" măkăl	" daughter
11	" grandson	ha-yä'-da	" grandson	" pêrăn	" grandson
12	" granddaughter	ka-yä'-da	" granddaughter	" pêrtti	" granddaughter
13	" great-grandson	ha-yä'-da	" grandson	" irandám pêrăn	" 2d grandson
14	" great-granddaughter	ka-yä'-da	" granddaughter	" " pêrtti	" " granddaughter
15	" great-grandson's son	ha-yä'-da	" grandson	" mŭndam pêrăn	" 3d grandson
16	" " " daughter	ka-yä'-da	" granddaughter	" " pêrtti	" " granddaughter
17	" elder brother	hä'-je	" elder brother	" tamaiyăn, bannăn	" elder brother
18	" " sister	ah'-je	" " sister	" akkàri, btămăkay	" " sister
19	" younger brother	ha'-gá	" younger brother	" tambi	" younger brother
20	" " sister	ka'-gá	" " sister	" tangaichchi, btangay	" " sister
21	" brothers	da-yä-guä-dan'-no-dä	" brothers	" săkothăree	" brothers (*Sanskrit*)
22	" sisters	"	" sisters	" săkothărckăl	" sisters "
23	" brother's son (*male speaking*)	ha-ah'-wuk	" son	" măkăn	" son
24	" " son's wife " "	ka'-säh'	" daughter-in-law	" mărŭmăkăl	" dau'ter-in-law & niece
25	" " daughter " "	ka-ah-wuk	" daughter	" măkăl	" daughter
26	" " daughter's husband " "	oc-na'-hosc	" son-in-law	" mărŭmăkăn	" son-in-law & nephew
27	" " grandson " "	ha-yä'-da	" grandson	" pêrăn	" grandson
28	" " granddaughter " "	ka-yä'-da	" granddaughter	" pêrtti	" granddaughter
29	" " great-grandson " "	ha-yä'-da	" grandson	" irandám pêrăn	" 2d grandson
30	" " " granddaughter " "	ka-yä'-da	" granddaughter	" " pêrtti	" " granddaughter
31	" sister's son " "	ha-yä'-wan-da	" nephew	" mărŭmăkăn	" nephew
32	" " son's wife " "	ka'-sä	" daughter-in-law	" măkăl	" daughter
33	" " daughter " "	ka-yä'-wan-da	" niece	" mărŭmăkăl	" niece
34	" " daughter's husband " "	oc-na'-hosc	" son-in-law	" măkăn	" son
35	" " grandson " "	ha-yä'-da	" grandson	" pêrăn	" grandson
36	" " granddaughter " "	ka-yä'-da	" granddaughter	" pêrtti	" granddaughter
37	" " great-grandson " "	ha-yä'-da	" grandson	" irandám pêrăn	" 2d grandson
38	" " " granddaughter " "	ka-yä'-da	" granddaughter	" " pêrtti	" " granddaughter
39	" brother's son (*female speaking*)	ha-soh'-neh	" nephew	" mărŭmăkăn	" nephew

	Description of Persons.	Relationship in Seneca-Iroquois.	Translation.	Relationship in Tamil.	Translation.
40	My brother's son's wife (*female speaking*)	ka'-sä	My daughter-in-law	En mäkäl	My daughter
41	" " daughter " "	ka-soh'-neh	" niece	" märŭmäkäl	" niece
42	" " daughter's husband " "	oc-na'-hosc	" son-in-law	" mäkan	" son
43	" " grandson " "	ha-yä'-da	" grandson	" pêrän	" grandson
44	" " granddaughter " "	ka-yä'-da	" granddaughter	" pêrtti	" granddaughter
45	" " great-grandson " "	ha-yä'-da	" grandson	" irandám pêran	" 2d grandson
46	" " " granddaughter " "	ka-yä'-da	" granddaughter	" " pêrtti	" " granddaughter
47	" sister's son " "	ha-ah'-wuk	" son	" mäkän	" son
48	" " son's wife " "	ka'-sä	" daughter-in-law	" märŭmäkäl	" dau'ter-in-law & niece
49	" " daughter " "	ka-ah'-wuk	" daughter	" mäkal	" daughter
50	" " daughter's husband " "	oc-na'-hosc	" son-in-law	" mäkän	" son
51	" " grandson " "	ha-yä'-da	" grandson	" pêrän	" grandson
52	" " granddaughter " "	ka-yä'-da	" granddaughter	" pêrtti	" granddaughter
53	" " great-grandson " "	ha-yä'-da	" grandson	" irandám pêrän	" 2d grandson
54	" " " granddaughter " "	ka-yä'-da	" granddaughter	" " pêrtti	" " granddaughter
55	" father's brother	hä'-nih	" father	" periya täkkäppän " serîya "	" great-father (*if older* " little-father (*if younger*
56	" " brother's wife	uc-no'-esc	" step-mother	" táy	" mother (*th'n my fath'r*)
57	" " " son (*older than myself*)	hä'-je	" elder brother	" tämaiyän	" elder brother
58	" " " " (*younger than myself*)	ha'-gä	" younger brother	" tambi	" younger brother
59	" " " son's wife	ah-ge-ah'-ne-ah	" sister-in-law	" maittuni (o.) anni (y.)	" cousin & sister-in-law
60	" " " daughter (*older than myself*)	ah-je	" elder sister	" akkarl b, tamakay	" elder sister
61	" " " " (*younger than myself*)	ka'-gä	" younger sister	" tangaichchi b, tangay	" younger sister
62	" " " daughter's husband	ha-yä'-o	" brother-in-law	" mäittŭnän	" broth'r-in-law & cous'n
63	" " " son's son (*male speaking*)	ha-ah'-wuk	" son	" mäkan	" son
64	" " " " " (*female* ")	ha-soh'-neh	" nephew	" märŭmäkän	" nephew
65	" " " " daughter (*male* ")	ka-ah'-wuk	" daughter	" mäkäl	" daughter
66	" " " " " (*female* ")	ka-soh'-neh	" niece	" märŭmäkäl	" niece
67	" " " daughter's son (*male* ")	ha-yä'-wän-da	" nephew	" märŭmäkän	" nephew
68	" " " " " (*female* ")	ha-ah'-wuk	" son	" mäkän	" son
69	" " " " daughter (*male* ")	ka-yä'-wän-da	" niece	" märŭmäkäl	" niece
70	" " " " " (*female* ")	ka-ah'-wuk	" daughter	" mäkäl	" daughter
71	" " " great-grandson	ha-yä'-da	" grandson	" pêrän	" grandson
72	" " " " granddaughter	ka-yä'-da	" granddaughter	" pêrtti	" granddaughter
73	" father's sister	ah-ga'-huc	" aunt	" attai	" aunt
74	" " sister's husband	hoc-no'-esc	" step-father	" máman	" uncle
75	" " " son (*male speaking*)	ah-gäre'-seh	" cousin	" attàn b, mäittŭnän	" cousin
76	" " " " (*female* ")	ah-gäre'-seh	" cousin	" mächchän	" "
77	" " " son's wife	ah-ge-ah'-ne-ah	" sister-in-law	" tangay	" younger sister
78	" " " daughter (*male speaking*)	ah-gäre'-seh	" cousin	" mäittuni	" cousin
79	" " " " (*female* ")	ah-gäre'-seh	" cousin	" mächchi b, mächchärl	" "
80	" " " daughter's husband	ha-yä-o'	" brother-in-law	" annan (o.) tambi (y.)	" elder or younger bro'r
81	" " " son's son (*male speaking*)	hä-ah'-wuk	" son	" märŭmäkän	" nephew
82	" " " " " (*female* ")	ha-soh'-neh	" nephew	" mäkän	" son

83	My father's sister's son's daughter	(male speaking)	ka-ah'-wuk	My daughter	En mărŭmăkăl	My niece
84	“ “ “ “ “	(female “)	ka-soh'-neh	“ niece	“ măkăl	“ daughter
85	“ “ “ daughter's son	(male “)	ha-yä'-wän-da	“ nephew	“ măkăn	“ son
86	“ “ “ “ “	(female “)	ha-ah'-wuk	“ son	“ mărŭmăkăn	“ nephew
87	“ “ “ “ daughter	(male “)	ka-yä'-wän-da	“ niece	“ măkăl	“ daughter
88	“ “ “ “ “	(female “)	ka-ah'-wuk	“ daughter	“ mărŭmăkăl	“ niece
89	“ “ “ great-grandson		ha-yä'-da	“ grandson	“ pêrăn	“ grandson
90	“ “ “ “ granddaughter		ka-yä'-da	“ granddaughter	“ pêrtti	“ granddaughter
91	“ mother's brother		hoc-no'-seh	“ uncle	“ mămăn	“ uncle
92	“ “ brother's wife		ah-gä-nĕ-ah	“ aunt-mother	“ mămē	“ aunt
93	“ “ “ son	(male speaking)	ah-gäre'-seh	“ cousin	“ măittŭnăn	“ cousin
94	“ “ “ “	(female “)	ah-gäre'-seh	“ cousin	“ măchchăn	“ “
95	“ “ “ son's wife		ah-ge-ah'-ne-ah	“ sister-in-law	“ tăngay	“ younger sister
96	“ “ “ daughter	(male speaking)	ah-gäre'-seh	“ cousin	“ măittŭni	“ cousin
97	“ “ “ “	(female “)	ah-gäre'-seh	“ cousin	“ măchchărl	“ “
98	“ “ “ daughter's husband		ha-yä'-o	“ brother-in-law	“ annan (o.) tambi (y.)	“ elder or younger bro'r
99	“ “ “ son's son	(male speaking)	ha-ah'-wuk	“ son	“ mărŭmăkăn	“ nephew
100	“ “ “ “ “	(female “)	ha-soh'-neh	“ nephew	“ măkăn	“ son
101	“ “ “ “ daughter	(male “)	ka-ah'-wuk	“ daughter	“ mărŭmăkăl	“ niece
102	“ “ “ “ “	(female “)	ka-soh'-neh	“ niece	“ măkăl	“ daughter
103	“ “ “ daughter's son	(male “)	ha-yä'-wän-da	“ nephew	“ măkăn	“ son
104	“ “ “ “ “	(female “)	ha-ah'-wuk	“ son	“ mărŭmăkăn	“ nephew
105	“ “ “ “ daughter	(male “)	ka-yä'-wän-da	“ niece	“ măkăl	“ daughter
106	“ “ “ “ “	(female “)	ka-ah'-wuk	“ daughter	“ mărŭmăkăl	“ niece
107	“ “ “ great-grandson		ha-yä'-da	“ grandson	“ pêrăn	“ grandson
108	“ “ “ “ granddaughter		ka-yä'-da	“ granddaughter	“ pêrtti	“ granddaughter
109	“ mother's sister		no-yeh'	“ mother	“ pêriyă tây (if older than, “ sĕriyă “ (if y'r my m'er)	“ mother, great or little
110	“ “ sister's husband		hoc-no'-ceh	“ step-father	“ takkăppăn (P. or S.)	“ father, “ “
111	“ “ “ son	(older than myself)	hä'-je	“ elder brother	“ tăniaiyăn, b, annan	“ elder brother
112	“ “ “ “	(younger “ “)	ha'-gä	“ younger brother	“ tambi	“ younger brother
113	“ “ “ son's wife		ah-ge-ah'-ne-ah	“ sister-in-law	“ măittŭni	“ sister-in-law & cousin
114	“ “ “ daughter	(older than myself)	ah'-je	“ elder sister	“ akkârl b, tămăkay	“ elder sister
115	“ “ “ “	(younger “ “)	ka'-gä	“ younger sister	“ tangăichchi, b, tangay	“ younger sister
116	“ “ “ daughter's husband		ha-yä'-o	“ brother-in-law	“ măittŭnăn	“ bro'r-in-law & cousin
117	“ “ “ son's son	(male speaking)	ha-ah'-wuk	“ son	“ măkăn	“ son
118	“ “ “ “ “	(female “)	ha-soh'-neh	“ nephew	“ mărŭmăkăn	“ nephew
119	“ “ “ “ daughter	(male “)	ka ah-wuk	“ daughter	“ măkăl	“ daughter
120	“ “ “ “ “	(female “)	ka-soh'-neh	“ niece	“ mărŭmăkăl	“ niece
121	“ “ “ daughter's son	(male “)	ha-yä-wän-da	“ nephew	“ mărŭmăkăn	“ nephew
122	“ “ “ “ “	(female “)	ha-ah'-wuk	“ son	“ măkăn	“ son
123	“ “ “ “ daughter	(male “)	ka-yä'-wän-da	“ niece	“ mărŭmăkăl	“ niece
124	“ “ “ “ “	(female “)	ka-ah'-wuk	“ daughter	“ măkăl	“ daughter
125	“ “ “ great-grandson		ha-yä'-da	“ grandson	“ pêrăn	“ grandson
126	“ “ “ “ granddaughter		ka-yä'-da	“ granddaughter	“ pêrtti	“ granddaughter
127	“ father's father's brother		hoc'-sote	“ grandfather	“ paddăn (P. and S.)	“ grandfather, g't or lit.
128	“ “ “ brother's son		hä'-nih	“ father	“ takkăppăn (P. and S.)	“ father, great or little

	Description of Persons.	Relationship in Seneca-Iroquois.	Translation.	Relationship in Tamil.	Translation.
129	My father's father's brother's son's son (*older than myself*)	hä'-je	My elder brother	En annan, b, tămäiyăn	My elder brother
130	" " " " " " (*younger* " ")	ha'-gă	" younger brother	" tambi	" younger brother
131	" " " " " son's son (*male speaking*)	ha-ah'-wuk	" son	" mäkăn	" son
132	" " " " " " " (*female* ")	ka-soh'-neh	" nephew	" mărŭmăkăn	" nephew
133	" " " " " " daughter (*male* ")	ka-ah'-wuk	" daughter	" măkăl	" daughter
134	" " " " " " " (*female* ")	ka-soh'-neh	" niece	" mărŭmăkăl	" niece
135	" " " " great-great-grandson	ha-yä'-da	" grandson	" pêrăn	" grandson
136	" " " " " " granddaughter	ka-yä'-da	" granddaughter	" pêrtti	" granddaughter
137	" father's father's sister	oc'-sote	" grandmother	" păddi (P. & S.)	" grandmother, g't or lit.
138	" " " sister's daughter	ah-ga'-huc	" aunt	" táy (P. and S.)	" mother, great or little
139	" " " " daughter's daughter (*male speaking*)	ah-găre'-seh	" cousin	" tămákăy (o.) tăngăy (y.)	" elder or younger sister
140	" " " " " " (*female* ")	ah-găre'-seh	" cousin	" tămákăy (o.) tăngăy (y.)	" " " "
141	" " " " " daughter's son (*male* ")	ha-yä'-wän-da	" nephew	" mărŭmakăn?	" nephew
142	" " " " " " " (*female* ")	ha-ah'-wuk	" son	" mäkăn?	" son
143	" " " " " " daughter (*male* ")	ka-yä'-wän-da	" niece	" mărŭmakăl?	" niece
144	" " " " " " " (*female* ")	ka-ah-wuk	" daughter	" măkăl?	" daughter
145	" " " " great-great grandson	ha-yä'-da	" grandson	" pêrăn	" grandson
146	" " " " " " granddaughter	ka-yä'-da	" granddaughter	" pêrtti	" granddaughter
147	" mother's mother's brother	hoc'-sote	" grandfather	" păddăn (P. and S.)	" grandfather, g't or lit.
148	" " " brother's son	hoc-no-seh	" uncle	" mämăn	" uncle
149	" " " " son's son (*male speaking*)	ah-găre'-seh	" cousin	" mäittŭnăn	" cousin
150	" " " " " " (*female* ")	ah-găre'-seh	" cousin	" mächchăn	" "
151	" " " " " son's son (*male* ")	ha-ah'-wuk	" son	" mărŭmăkăn	" nephew
152	" " " " " " " (*female* ")	ha-soh'-neh	" nephew	" măkăn	" son
153	" " " " " " daughter (*male* ")	ka-ah'-wuk	" daughter	" mărŭmăkăl	" niece
154	" " " " " " " (*female* ")	ka-soh'-neh	" niece	" măkăl	" daughter
155	" " " " great-great grandson	ha-yä'-da	" grandson	" pêrăn	" grandson
156	" " " " " " granddaughter	ka-yä'-da	" granddaughter	" pêrtti	" granddaughter
157	" mother's mother's sister	oc'-sote	" grandmother	" păddi (P. and S.)	" grandmother, g't or lit.
158	" " " sister's daughter	no-yeh'	" mother	" táy (P. and S.)	" mother, great or little
159	" " " " daughter's daughter (*older than myself*)	ah'-je	" elder sister	" tămăkăy	" elder sister
160	" " " " " " (*younger* " ")	ka'-ga	" younger sister	" tăngăy	" younger sister
161	" " " " " daughter's son (*male speaking*)	ha-yä'-wän-da	" nephew	" mărŭmăkăn	" nephew
162	" " " " " " " (*female* ")	ha-ah'-wuk	" son	" măkăn	" son
163	" " " " " " daughter (*male* ")	ka-yä'-wän-da	" niece	" mărŭmăkăl	" niece
164	" " " " " " " (*female* ")	ka-ah'-wuk	" daughter	" măkăl	" daughter
165	" " " " great-great grandson	ha-yä'-da	" grandson	" pêrăn	" grandson
167	" " " " " " granddaughter	ka-yä'-da	" granddaughter	" pêrtti	" granddaughter
168	My father's father's father's brother	hoc'-sote	" grandfather	" irandám păddăn	" 2d grandfather
169	" " " " brother's son	hoc'-sote	" grandfather	" păddăn (P. and S.)	" grandfather, g't or lit.
170	" " " " " son's son (*older than myself*)	hä'nih	" father	" tăkăppăn (P. and S.)	" father, great or little
171	" " " " " " son's son (*male speaking*)	ha-ah'-wuk	" son	" măkăn	" son
172	" " " " " " " son's son	ha-yä'-da	" grandson	" pêrăn	" grandson
173	" " " " "	oc'-sote	" grandmother	" irandám păddi	" 2d grandmother

174	My father's father's father's sister's daughter	oc'-sote	My grandmother	En pāddi (P. and S.)	My grandmother, g't or lit.
175	" " " " " daughter's daughter	no-yeh'	" mother	" táy (P. and S.)	" mother, great or little
176	" " " " " " dau'ters dau'ter (*male speaking*)	ah'-je	" elder sister	" tāmākāy b, tāngāy?	" sister, elder or younger
177	" " " " " " " daughter's daughter	ha-soh'-neh	" niece	" mārūmākāl	" niece
178	" " " " " " " " daughter's daughter	ha-yä'-da	" granddaughter	" pêrtti	" granddaughter
179	" mother's mother's mother's brother	hoc'-sote	" grandfather	" irandám pāddān	" 2d grandfather
180	" " " " brother's son	hoc'-sote	" grandfather	" pāddān (P. or S.)	" grandfather, g't or lit.
181	" " " " " son's son	hoc-no'-seh	" uncle	" mámān	" uncle
182	" " " " " " son's son (*male speaking*)	ah-gäre'-seh	" cousin	" māittūnān	" cousin
183	" " " " " " " son's son (*female* ")	ha-ah'-wuk	" son	" mārūmākān	" nephew
184	" " " " " " " " son's son	ha-yä'-da	" grandson	" pêrān	" grandchild
185	" mother's mother's mother's sister	oc'-sote	" grandmother	" irandám pāddi	" 2d grandmother
186	" " " " sister's daughter	oc'-sote	" grandmother	" pāddi (P. or S.)	" grandmother, g't or lit.
187	" " " " " daughter's daughter	no-yeh'	" mother	" táy (P. or S.)	" mother, great or little
188	" " " " " " dau'ter's dau'ter (*older than myself*)	ah'-je	" elder sister	" akkárl	" elder sister
189	" " " " " " " dau'ter's dau'ter (*female speaking*)	ka-yä'-wān-da	" niece	" mākāl	" daughter
190	" " " " " " " " daughter's daughter	ka-yä'-da	" granddaughter	" pêrtti	" granddaughter
191	" husband	da-yake'-ne	" husband	" kānavān, b, purnshan	" husband
192	" wife	da-yake'-ne	" wife	" māinavi, b, pernchátti	" wife
193	" husband's father	hä-ga'-sä	" father-in-law	" mámān, b, mámanār	" uncle & father-in-law
194	" " mother	ong-ga'-sä	" mother-in-law	" mámi, b, mánnai	" aunt & mother-in-law
195	" wife's father	oc-na'-hosc	" father-in-law	" māmān	" uncle & father
196	" " mother	oc-na'-hosc	" mother-in-law	" mámi	" aunt
197	" son-in-law	oc-na'-hosc	" son-in-law	" māpillai, b, mārūmākān	" son-in-law & nephew
198	" daughter-in-law	ka'-sä	" daughter-in-law	" marūmākal	" dau'ter-in-law & niece
199	" step-father	hoc-no'-esc	" step-father		(Widows cannot marry.)
200	" " mother	oc-no'-esc	" step-mother	" sēriya táy	my little mother
201	" " son	ha'-no	" step-son	" mākān	" son
202	" " daughter	ka'-no	" step-daughter	" mākāl	" daughter
203	" " brother			" annan (o.) tambi (y.)	" bro'r, older or younger
204	" " sister			" akkári (o.) tāngāy (y.)	" sister, " "
205	" brother-in-law (*husband's brother*)	ha-yä'-o	" brother-in-law	" māittūnān	" bro'r-in-law & cousin
206	" " " (*sister's husband, male speaking*)	ah-ge-ah'-ne-o	" " "	" māittūnān	" " " "
207	" " " (" " *female* ")	ha-yä'-o	" " "	" attan (o) maichchān (y.)	" " " "
208	" " " (*wife's brother*)	ah-ge'ah'-ne-o	" " "	" māittūnān	" " " "
209	" " " (*wife's sister's husband*)	no relation		" sakālān	" " " "
210	" " " (*husband's sister's husband*)	no relation		" sakotaran	" " " "
211	" sister-in-law (*wife's sister*)	ka-yä'-o	" sister-in-law	" korlunti (o.) māittūini	" sister-in-law & cousin
212	" " " (*husband's sister*)	ah-ge-ah'-ne-o	" " "	" nāttānae	" " " "
213	" " " (*brother's wife, male speaking*)	ka-yä'-o	" " "	" anni (o.) māittūni (y.)	" " "
214	" " " (*brother's wife, female speaking*)	ah-ge-ah'-ne-o	" " "	" anni (o.) māittūni (y.)	" " "
215	" " " (*husband's brother's wife*)	no relation		" orakatti	" " " "
216	" " " (*wife's brother's wife*)	no relation		" tāmākāy (o.) tāngāy (y.)	" " " "
217	" widow	go-no-kw'-yes'-hä'-ah widow		" kiempun	widow.
218	" widower	ho-no-kw'-yes'-hä'-ah widower			
219	" twins	tas-geek'-hä	twins	Dithambathie	twins (Sanskrit)

The identity of the Seneca-Iroquois and the Tamil is demonstrated by a bare inspection. It is no part of my present purpose to attempt to show how this identity can be explained; but it may be premised that there are but four hypotheses conceivable for its explanation, which are the following: — 1. By borrowing one from the other. 2. By accidental invention by different peoples in disconnected areas; treating the system as arbitrary and artificial. 3. By spontaneous growth or development in similar conditions of society and in disconnected areas; treating the system as natural. 4. By inheritance, with the blood, from a common original source.

The first assumes territorial connection, and the consequent Asiatic origin of the Ganowanian family: and it may therefore be dismissed. The second is an impossible hypothesis. As the system embodies upwards of twenty independent particulars, the improbability of their accidental concurrence in the Seneca-Iroquois and the Tamil increases with the addition of each particular from the first to the last; becoming, finally, an impossibility. The third hypothesis is substantial. It assumes that the system is natural in its origin, and in accordance with the nature of descents; consequently, it must further assume that the ancestors of the Seneca-Iroquois and of the Tamilian people of India, if created in separate and independent zoölogical provinces, must not only have passed through the same experiences, but also have developed, through great reformatory movements, precisely the same sequence of customs and institutions, to have wrought out by natural development or organic growth the Ganowanian system in America and the Turanian system in Asia; the two remaining identical after having been transmitted with the blood through centuries of time. It will be found, in the sequel, and after the most critical examination, that the fourth hypothesis, that of its transmission with the blood from common ancestors, will prove the most satisfactory.

I am aware that the foregoing presentation of the Aryan, Malayan, Ganowanian, and Turanian systems of relationship is far too brief and incomplete to render entirely satisfactory the following solution of the origin of the classificatory system. But it will serve to indicate some of the conclusions to which the facts appear to tend.

The origin of the classificatory system, in view of its character and spread among the families of mankind, becomes a matter of deep importance. It is to be presumed that the recognized relationships were those which actually existed at the time the system was formed. If

this be true, then the system embodies a record of primitive customs and institutions of great significance. We have seen that the system of the Aryan family is a natural system, following the streams of the blood; but that it was founded upon marriage between single pairs. Wherefore it rests exclusively upon this form of marriage, and not upon natural suggestion. It is, at least, supposable that a state of society might have existed in the primitive ages in which marriage between single pairs, as well as the family in its modern sense, was entirely unknown. Whilst mankind were in this state, a system of consanguinity might have arisen entirely different from the Aryan form, and yet follow the streams of the blood, and be in strict accordance with the nature of descents. For example, it might rest, as before intimated, upon compound marriages in a communal family. In some such state of society as this the classificatory system must have originated.

I propose to take up the Malayan system of relationship as the earliest stage of the classificatory, and to submit a conjectural solution of its origin upon the assumed concurrent existence of certain customs and institutions. It will rest for the most part upon the assumed *intermarriage or cohabitation of brothers and sisters* in a communal family. After this I shall present a further conjectural solution of the origin of the remainder, or Turanian portion of the system, upon the basis of the *Tribal Organization*. These are the essential conditions; but they draw to themselves other customs and institutions of hardly secondary importance.

These solutions will enable us to construct upon them, as foundations, a great series of customs and institutions, in the order of their development, by means of which the human family raised itself through a long and savage experience from a state of promiscuous intercourse to a knowledge of the family in its modern sense.

Mankind, if one in origin, must have become subdivided at a very early period into independent nations, followed by the rapid formation of dialects and stock-languages, the latter repeated over and over again to the present time. Unequal progress has been made by these several stocks. Some of them still remain in a condition not far removed from the primitive; others are found in all the intermediate stages of progress on to complete civilization. It is not improbable that all the customs and institutions of mankind which have arisen at different epochs are still existing in some portions of the human family. Those

which have been most effective for man's advancement must have been of slow growth, and of still slower diffusion among the nations. They are to be regarded as the great remaining landmarks of man's progress, whilst the mass of minor influences which contributed to their adoption have fallen out of knowledge.

The customs and institutions relating to the family state, and in the probable order of their orgination, may be stated as the following: —

I. Promiscuous Intercourse.
II. Intermarriage, or Cohabitation, of Brothers and Sisters. Giving
III. The Communal Family. (First Stage of the Family.)
IV. The Hawaiian Custom. Giving, with II.,
V. The Malayan Form of the Classificatory System of Relationship.
VI. The Tribal Organization. Giving
VII. The Turanian and Ganowanian Systems of Relationship.
VIII. Marriage between Single Pairs. Giving
IX. The Barbarian Family. (Second Stage of the Family.)
X. Polygamy. Giving
XI. The Patriarchal Family. (Third Stage of the Family.)
XII. Polyandria.
XIII. The Rise of Property, with the Settlement of Lineal Succession to Estates. Giving
XIV. The Civilized Family. (Present Stage of the Family.) Causing
XV. The Overthrow of the Classificatory System of Relationship, and the Substitution of the Descriptive.

Given, the second and fourth customs, the origin of the Malayan system can be demonstrated from the nature of descents, and the relationships shown to be those actually existing. In like manner, the second, fifth, and sixth of these customs and institutions being given, the origin of the Turanian and Ganowanian systems can be explained in the same manner, and to the same effect. Whether, given the Turanian system of relationship, the antecedent existence of these customs and institutions can be legitimately inferred, will depend upon the probability of their prevalence from the nature of human society, and from what is known of its previous conditions. It may be confidently affirmed that this great sequence of customs and institutions, although in part hypothetical, will organize and explain the body of ascertained

facts, with respect to the primitive condition of mankind, in a manner so singularly and surprisingly adequate as to invest it with a strong probability of truth.

All of these, except the first three, have existed within the historical period, and still prevail in large portions of the human family. The assumption, as to them, is limited to their mutual relations as members of a series.

With respect to the first three, namely, Promiscuous Intercourse, the Intermarriage of Brothers and Sisters, and the Communal Family, their prevalence will be assumed; although there is strong evidence tending to render probable the first two, and decisive evidence of the existence of communal families in the barbarous nations of the present time.

The Hawaiian custom, which has been explained, is the fourth in the series. It is a compound form of polygynia and polyandria, since, under one of its branches, the several brothers live in polygynia, and their wives in polyandria; and, under the other, the several sisters live in polyandria, and their husbands in polygynia. In other words, it is promiscuous intercourse within prescribed limits. Its existence, as a custom, seems to imply antecedent unregulated promiscuous intercourse, involving the cohabitation of brothers and sisters as its most common form; thus finding mankind in a state akin to that of the inferior animals. It seems probable that the Hawaiian custom still embodies the evidence of an organic movement of society to extricate itself from a worse condition than the one it produced. In effect, it was a compact between several brothers to defend their common wives, and a like compact between the husbands of several sisters to defend their common wives, against the violence of society; thus implying the existence of a perpetual struggle amongst the males for the possession of the females.

And this brings us to an important general proposition, namely, that the principal customs and institutions of mankind have originated in, and can only be explained as, great reformatory movements of society. If this sufficiently explains the origin of the Hawaiian custom, it must be regarded as one of a series of similar movements, by means of which mankind emerged from a state of promiscuous intercourse, and through a long and painful experience attained to marriage between single pairs, and finally to the family as it now exists.

I propose now to submit a conjectural solution of the origin of the

Malayan system upon the basis of the assumed intermarriage of brothers and sisters, and upon the Hawaiian custom.

It will be remembered that under this system the primary relationships only are recognized and named. These terms are applied to consanguinei in a definite manner, by means of which they are reduced to as many great classes as there are primary relationships. No distinction is made between lineal and collateral consanguinei, except that they are distributed into classes. In a word, all consanguinei are either fathers or mothers to each other, or brothers or sisters, sons or daughters, grandparents or grandchildren. It follows that a knowledge of the degrees, numerically, forms an integral part of the system, with certainty of parentage within prescribed limits.

I. All the children of my several brothers, myself a male, are my sons and daughters. Reason: I cohabit with all my brothers' wives, who are my own wives as well (using the terms *husband* and *wife* in the sense of the custom). As it would be impossible for me to distinguish my own children from those of my brothers, if I call any one my child, I must call them all my children. One is as likely to be mine as another.

II. All the grandchildren of my several brothers are my grandchildren. Reason: They are the children of my sons and daughters.

III. With myself a female, the foregoing relationships are the same. The reason must be sought in the analogies of the system. As my several brothers are my husbands, their children by other wives would be my step-children, which relationship being unrecognized they naturally fall into the category of my sons and daughters. These must be the relationships, or none.

IV. All the children of my several sisters, myself a male, are my sons and daughters. Reason: I cohabit with all my sisters, who are my wives.

V. All the grandchildren of my several sisters are my grandchildren. Reason: They are the children of my sons and daughters.

VI. All the children of my several sisters, myself a female, are my sons and daughters. Reason: I cohabit with all the husbands of my sisters, who are my husbands as well. This difference, however, exists. I can distinguish my own children from those of my sisters, to the latter of whom I am a step-mother. But since this relationship is not discriminated they fall into the category of sons and daughters.

VII. All the children of several own brothers are brothers and sisters to each other. Reason: These brothers cohabit with all the mothers of these children. Among their reputed fathers none of these children can distinguish their own father; but among the wives of these several brothers, they can distinguish their own mother: whence, as to the former, they are brothers and sisters to each other, but as to the latter, whilst the children of a common mother are brothers and sisters to each other, these are step-brothers and step-sisters to the children of their mother's sisters. They thus, for reasons stated in similar cases, fall into the relationships of brother and sister.

VIII. The children of these collateral brothers and sisters are also brothers and sisters to each other; the children of the latter are brothers and sisters again; and these relationships continue downward amongst their descendants indefinitely, at equal removes from the common ancestor. An infinite series is thus created, which becomes a fundamental part of the system. It is not easily explained. The Hawaiian custom, as stated, is limited to several own brothers and their wives, and to several own sisters and their husbands. To account for this infinite series, it must be further assumed that this privilege of barbarism extended wherever the relationship of brother and sister was recognized to exist; each brother having as many wives as he had sisters, and each sister having as many husbands as she had brothers, whether own or collateral.

IX. All the children of several own sisters are brothers and sisters to each other; all their children are brothers and sisters again; and so downward indefinitely. Reasons as in VII. and VIII.

X. All the children of several own brothers on the one hand, and of their several own sisters on the other, are brothers and sisters to each other; the children of the latter are brothers and sisters again; and so downward indefinitely. Reasons as in VII. and VIII.

XI. All the brothers of my father are my fathers; and all the sisters of my mother are my mothers. Reasons as in I., III., and VI.

XII. All the sisters of my father are my mothers; and all the brothers of my mother are my fathers. Reasons: My father cohabits with all his sisters, and my mother cohabits with all her brothers.

XIII. All the children of my collateral brothers and sisters are, without distinction, my sons and daughters. Reasons as in I., III., IV., and VI.

XIV. All the children of the latter are my grandchildren. Reasons as in II.

XV. All the brothers and sisters of my grandfather, and all the brothers and sisters of my grandmother, are my grandparents. Reason: They are the fathers and mothers of my father and mother.

Every blood-relationship recognized under the Malayan system is thus explained from the nature of descents, and is seen to be the one actually existing, as near as the parentage of the individual could be known, with the exception of a limited number, which seem to have originated in the analogies of the system. The system, therefore, follows the streams of the blood, instead of thwarting or diverting its currents. It appears to have originated in the intermarriage or cohabitation of brothers and sisters in a communal family, the assumption of which, as a custom, is necessary to explain its origin from the nature of descents. When the Hawaiian custom, which finds its type in the intermarriage of brothers and sisters, intervened, it brought into the communal family other males and females; but it must have left the previous usage unaffected, otherwise several of the Malayan relationships would have become untrue to the nature of descents, and changed, as we shall hereafter see, in the case of the Turanian and Ganowanian systems.

The origin of the several marriage relationships may be explained, with more or less of certainty, upon the same principles.

This solution of the origin of the Malayan system, although it rests, aside from the Hawaiian custom, upon the assumed intermarriage of brothers and sisters, is sufficiently probable in itself to deserve serious attention. It reveals a state of society in the primitive ages, not confined to the islands of the Pacific, with the evidence of its actual existence still preserved in this system of relationship, which we shall be reluctant to recognize as real, and yet toward which evidence from other and independent sources has long been pointing. It finds mankind, during the period anterior to the Hawaiian custom, in a barbarism so profound that its lowest depths can scarcely be imagined. It is partially shadowed forth by the fact, that neither the propensity to pair, now so powerfully developed, nor marriage in its proper sense, nor the family, except the communal, were known; and, above all, that the sacredness of the tie which binds brother and sister together, and raises them above the temptations of animal passion, had not then dawned upon the barbarian mind.

In the next place we are to submit a conjectural solution of the

origin of the remainder, or Turanian portion of the system upon the basis of the tribal organization.

No evidence has been presented of the prevalence of the Hawaiian custom in Asia or America, or of the intermarriage of brothers and sisters as a general custom. Neither is it necessary for the purpose in hand that such evidence should exist. This solution is founded upon the assumed existence of the Malayan system in Asia anterior to the epoch of the tribal organization; and if these together are sufficient to explain the origin of the Turanian system, this system then becomes to some extent evidence of the existence of both customs, as well as of the Malayan system in Asia.

The Turanian system was undoubtedly engrafted upon an original form agreeing in all essential respects with the Malayan. About half of the Malayan relationships must be changed, leaving the other half as they are, to produce the Turanian system. It is clear that the Malayan could not be derived from the Turanian, since the former is the simpler, and therefore the older form; neither could the Turanian be developed out of the Malayan, since it contains additional and distinctive elements. But a great change of social condition might have occurred which would supply the new element; and such, in all probability, was the history of the transition from the one into the other. How this change was effected is the question. It will be seen, at a glance, that it was only necessary to break up the intermarriage of brothers and sisters, to change the Malayan into the Turanian form, provided the changes in parentage, thus produced, were followed to their logical results.

Following, step by step, the supposed sequence of customs and institutions which developed the classificatory system of relationship by organic growth, it will next be assumed that the Malayan form, as its first stage, prevailed upon the continent of Asia, among the ancestors of the present Turanian family, at the epoch of the Malayan migration to the islands of the Pacific. In other words, it may be conjectured that the Malayan family took with them from Asia the form which then prevailed, and preserved it to the present time, whilst they left the same form behind them in the stock from which they separated. With the Malayan system thus prevalent in Asia, it may be supposed that another great organic movement of society occurred, which resulted, in the course of time, in the establishment of the tribal organization. This institution is so ancient and so wide-spread that its origin must

ascend far back toward the primitive ages of mankind. It still prevails, or has prevailed, among the principal Asiatic and American Indian nations, and also among the ancestors of several of the present Aryan nations. It is explainable, in its origin, and only explainable, as a reformatory movement to break up the intermarriage of blood relations, and particularly of brothers and sisters, by compelling them to marry out of the tribe. With the prohibition of intermarriage in the tribe, the cohabitation of brothers and sisters was permanently abolished, since they were necessarily of the same tribe. It would neither overthrow the Hawaiian custom, although it abridged its range, nor the communal family, which harmonized with tribal life; but it struck at the roots of promiscuous intercourse by abolishing its worst features, and thus became a powerful movement toward the ultimate realization of marriage between single pairs and the true family state.

A tribe is a group of consanguinei, with descent limited either to the male or to the female line. Where descent is limited to the male line, the tribe would consist of a supposed male ancestor and his children, together with the descendants of his sons in the male line forever. It would include this ancestor and his children, the children of his sons, and all the children of his lineal male descendants, whilst the children of the daughters of this ancestor, and all the children of his female descendants, would be transferred to the tribes of their respective fathers. Where descent is limited to the female line, the tribe would consist of a supposed female ancestor and her children, together with the descendants of her daughters in the female line forever. It would include the children of this ancestor, the children of her daughters, and all the children of her lineal female descendants, whilst the children of the sons of this ancestor, and all the children of her male descendants, would be transferred to the tribes of their respective mothers. Modifications of this form of the tribe may have existed, but this is the substance of the institution. No man can marry a woman of his own tribe, whether descent is in the male or female line. All of its members are consanguineal. This prohibition is a fundamental characteristic of the tribal organization. The knowledge of a common tribal descent is preserved by a tribal name, such as wolf, bear, or horse.

If the principles resulting from the tribal organization, so far as they relate to parentage, are now applied to that part of the Turanian system, which is distinctively Turanian, the relationships will be found to be those actually existing, and to be in accordance with the nature

of descents. It will also interpret the manner in which the Turanian element became incorporated in the system.

I. All the children of my several sisters, myself a male, are my nephews and nieces. Reason: Since under the tribal organization my sisters ceased to be my wives, their children can no longer be my children, as in the Malayan, but must stand to me in a different and more remote relationship. Whence the origin of the relationships of nephew and niece.

II. All the children of these nephews and nieces are my grandchildren. This can only be explained from the analogy of the system. No relationships outside of nephew, cousin, and grandson, are recognized; that of grandchild, being the one recognized under the previous system, would be apt to remain until a new relationship was created.

III. All the children of my several brothers are still my sons and daughters. Reason: The tribal organization does not prevent my brother's wives from being my wives as well. The changes in the system are confined exclusively to those which depended upon the intermarriage of brothers and sisters.

IV. All the children of my several brothers, myself a female, are my nephews and nieces; and all their children are my grandchildren. Reasons as in I. and II.

V. All the children of my several sisters, myself a female, are still my sons and daughters; and their children are my grandchildren. Reason: I cohabit with all the husbands of my several sisters, who are my own husbands as well.

VI. All the sisters of my fathers are my aunts. Reasons: Since, under the tribal organization, my father does not cohabit with his sisters, they can no longer stand to me in the relation of mothers, but must be placed in one more remote. Whence the relationship of aunt.

VII. All the brothers of my mother are my uncles. Reason as in VI. Whence the relationship of uncle.

VIII. All the children of my several uncles and aunts are my cousins. Reasons as in VI. Since they cannot be my brothers and sisters, for the reasons named, they must stand to me in a more remote relationship.

IX. All the children of my father's brothers are my brothers and sisters, and so are all the children of my mother's sisters, as in the Malayan, and for the reasons there given.

X. All the children of my male cousins, myself a male, are my nephews and nieces, and all the children of my female cousins are my

sons and daughters. Such is the classification in the nations of South-India. Unless I cohabit with all my female cousins, and am excluded from cohabitation with the wives of my male cousins, these relationships cannot be explained from the nature of descents. In the American Indian family this classification is reversed; the children of my male cousins, myself a male, are my sons and daughters, and of my female cousins are my nephews and nieces. The latter are explainable from the analogy of the system. It is a singular fact that the deviation upon these relationships is the only one of any importance between the Tamil and the Seneca-Iroquois. It has undoubtedly a logical explanation of some kind. If it is attributable to the slight variation upon this privilege of barbarism above indicated, a singular solution of the difference in the two systems is thereby afforded.

XI. All the brothers of my grandfather and of my grandmother are, without distinction, my grandfathers and grandmothers. Reasons as to former same as in the Malayan; as to the latter, the analogy of the system.

The same course of explanation can be applied to the more remote collateral lines, and to several of the marriage relationships, with substantially the same results; but the solution has been carried far enough for my present purpose. All of the indicative relationships of the classificatory system have now been explained, and are seen to be the relationships which existed in the communal family, as constituted first under the Malayan system, and ultimately under the Turanian. If the progressive conditions of society in the ages of barbarism, from which this solution is drawn, are in part hypothetical, the system itself, as thus explained, is found to be of organic growth, as well as simple and natural. In any other view it must be regarded as an artificial and arbitrary creation of human intelligence. The probable existence of this series of customs and institutions, so far as their existence is assumed, is greatly strengthened by the simplicity of the solution which they afford of the origin of the classificatory system in two great stages of development.

An exposition of the entire series of customs and institutions named together with a discussion of the historical evidence relating to each of them, are necessary to a full appreciation of the probable correctness of this solution. But they cover too wide a field, and embrace too many considerations, to be treated at the present time. I have presented the naked outline, and what seemed to be the controlling propositions. This discussion, at most, is but the introduction of the subject.

The present existence of the classificatory system, with the interna evidence of its transition from the Malayan to the Turanian form is in itself a powerful argument in favor of the existence of the customs and institutions previously assumed; and also in favor of the origination of the remainder of the series in the order stated. All except the first and second, and perhaps the fourth, still prevail in portions of the human family, and are known to have existed as far back in the past as the oldest historical records ascend, with abundant evidence of the previous existence of some of them from time immemorial.

It yet remains to present a few facts with reference to the order of their origination as a great progressive series founded upon the growth of man's experience, and also with reference to their reformatory character. The establishment of this series, as a means for recovering the thread of man's history through the primitive ages, is the principal result of this solution of the origin of the classificatory system.

For the purpose of presenting a few of these facts, it will be necessary to recapitulate the series.

1. Promiscuous Intercourse. — This expresses the lowest conceivable stage of barbarism in which mankind could be found. In this condition man could scarcely be distinguished from the mutes, except in the potential capacity of his endowments. Ignorant of marriage in its proper sense, of the family except the communal, and with the propensity to pair still undeveloped, he was not only a barbarian, but a savage, with a feeble intellect and a still feebler moral sense. His only hope of elevation rested in the fierceness of his passions, and in the improvable character of his nascent mental and moral powers. The lessening volume of the skull and its low animal characteristics, as we recede in the direction of the primitive man, deliver a decisive testimony concerning his immense inferiority to his civilized descendants. The implements of stone and flint found over the greater part of the earth attest the rudeness of his condition when he subsisted chiefly upon fish; leaving it doubtful whether, to become a fisherman, he had not raised himself from a still more humble condition. That the ancestors of the present civilized nations were, in the primitive ages, savages of this description, is not improbable; neither is it a violent supposition that they, as well as the ancestors of the present barbarous nations, once lived in a state of promiscuous intercourse, of which, as to the latter, their systems of consanguinity and affinity still embody the evi-

dence. To raise mankind out of this condition could only be accomplished by a series of reformatory movements, resulting in the development of a series of customs and institutions for the government of their social life. The anchorage secured by each of these customs and institutions tended to hold society in its advanced position, and to prevent a relapse.

2. Intermarriage, or Cohabitation, of Brothers and Sisters. — This practice, which the previous condition necessarily involved, would tend to regulate, as well as to check, the gregarious principle. It would probably be the normal condition of society under this principle; and, when once established, would be apt to perpetuate itself through indefinite, or, at least, immensely long, periods of time. It gives the starting-point and the foundation of the Malayan system of relationship, which, in turn, is the basis of the Turanian and Ganowanian. Without this custom it is impossible to explain the origin of the system from the nature of descents. There is, therefore, a necessity for the prevalence of this custom amongst the remote ancestors of all the nations which now possess the classificatory system, if the system itself is to be regarded as having a natural origin.

4. The Hawaiian Custom. — The existence of this custom is not necessary to an explanation of the origin of the Malayan system. All it contains bearing upon this question is found in the intermarriage of brothers and sisters, where the brothers live in polygynia and the sisters in polyandria; but it holds a material position in the series, for the reason that it was an existing and still prevalent custom in the Sandwich Islands at the epoch of their discovery. It finds its type in the previous custom, out of which it naturally arose. So far as it brought unrelated persons into the household, it was a positive advance upon the previous condition, tending to check promiscuous intercourse, and to relieve society from the evils of continuous intermarriage among blood relatives. It also tended to develop still further the idea of the communal family, and to move society in the direction of marriage between single pairs. Its reformatory character is implied from the fact, that it imposed upon the several brothers, who shared their wives in common, the joint obligation of their defence against the violence of society, the necessity for which would naturally exist in such a state of society as this custom presupposes.

5. The Communal Family. — Such a family resulted necessarily from the intermarriage of brothers and sisters. The union of effort

to procure subsistence for the common household led to communism in living. This probable organization of society in the primitive ages, and which continued long after the intermarriage of brothers and sisters was abolished, has not been sufficiently estimated in its relation to the early condition of mankind. Without being able to affirm the fact, there are strong grounds for supposing that most barbarous nations at the present time, although marriage between single pairs exists, are now organized more or less into such families, and practise communism as far as the same can be carried out in practical life. The American aborigines have lived, and still live, to a greater or less extent, in communal families, consisting of related persons, and practise communism within the household. This feature of their ancient mode of life can still be definitely and widely traced amongst them. It also entered into and determined the character of their architecture,—as witness the long bark house of the Iroquois, designed to accommodate twenty families of related persons; the polygonal dirt lodge of the Minnitarees and Mandans, designed for several families; the long houses of the Columbia River Indians, each large enough to accommodate several hundred persons; and, finally, the massive communal edifices of the Village Indians of New Mexico, Mexico, and Yucatan, some of them large enough for fifty or a hundred families, and giving rise to fables of *palaces*, which, without much doubt, were communal houses filled with Indians living in communism. In the communal family, as first described, is to be recognized the family in its first stage.

6. The Malayan System of Relationship.—This holds the rank of a domestic institution, and takes its place in the series as the basis of the Turanian system.

7. The Tribal Organization.—That this institution was designed to work out a reformation with respect to the intermarriage of brothers and sisters may be fairly inferred from the conspicuous manner in which it accomplishes this result. The state of society revealed by the Malayan system demonstrates its necessity. The origin of this most ancient and remarkable organization seems from the stand-point of this discussion to find a full and satisfactory explanation. It is not supposable that it came into existence all at once, as a complete institution; but rather that it was of organic growth, and required centuries upon centuries for its permanent establishment, and still other centuries for its spread amongst existing nations. It was probably the greatest of all the institutions of mankind in the primitive

ages in its influence upon human progress, as well as the most widely distributed in the human family. This gave, also, the Turanian system of relationship.

8. Marriage between Single Pairs. — Instances of marriage between single pairs may have, and probably did, occur in all periods of man's history; but they must have been exceptional, from the necessity of the case, in the primitive ages. After the tribal organization came into existence, and the cohabitation of brothers and sisters was broken up, as well as all intermarriage in the tribe, there must have been a very great curtailment of the license of barbarism. Women for wives became objects of negotiation out of the tribe, of barter, and of capture by force. The prevalence of these practices throughout Asia and America is well established. Wives thus gained by personal effort, and by purchase, would not be readily shared with others. In its general tendency it would lead to individual contracts to procure a single wife for a single husband, and thus tend directly to inaugurate marriage between single pairs. The immense influence of the tribal organization upon human progress toward the true family state cannot be overestimated.

9. The Barbarian Family. — In the early ages this stage of the family could scarcely be distinguished from the communal.

10. Polygamy. — In its relation to pre-existing customs and institutions polygamy is essentially modern. It presupposes a very great advance of society from its primitive condition, with settled governments, with stability of such kinds of property as existed, and with enlargement of the amount, as well as permanence, of subsistence. It seems to spring out of antecedent customs, akin to the Hawaiian, by natural suggestion. If this be so, then polygamy must be regarded as having been a reformatory institution. Considered from this standpoint, instead of a retrograde movement, it was a powerful advance in the direction of the true family.

11. The Patriarchal Family. — Polygamy resulted in the establishment of the patriarchal family, or the family in its third stage. A family with a single male head was an immense advance upon the communal. It necessitated, to some extent, a privileged class in society, before one person would be able to support several sets of children by several different mothers. Polygamy in its higher forms belongs to the dawning ages of civilization.

12. Polyandria. — This custom requires no further notice.

13. Property. Considered as an Institution. — It is impossible to overestimate the influence of property upon the civilization of mankind. It was the germ, and is still the evidence, of his progress from barbarism. The master passion of the civilized mind is for its acquisition and enjoyment. Governments, institutions, and laws, all resolve themselves into so many agencies designed for the creation and protection of property. But, above all, the desire of parents to transmit it to their children was the great turning-point between barbarism and civilization. When this desire, which arose with the development of property, was consummated by the introduction of lineal succession to estates, it revolutionized all the social ideas of barbarous society. Marriage between single pairs became the first condition to certainty of parentage; and thus, in course of time, became the rule, rather than the exception; the interests of property required individual ownership to stimulate personal exertion; and the protection of the state became necessary to render it stable. With the rise of property, considered as an institution, with the settlement of its rights, and, above all, with the established certainty of its transmission to lineal descendants, came the first possibility among mankind of the true family in its modern acceptation. All previous family states were but a feeble approximation.

14. The Family. — As now constituted, the family is founded upon marriage between one man and one woman. A certain parentage was substituted for a doubtful one; and the family became organized and individualized by property rights and privileges. The establishment of lineal succession to property as an incident of descent overthrew, among civilized nations, every vestige of pre-existing customs and institutions inconsistent with this form of marriage. The persistency with which the classificatory system has followed down the families of mankind to the dawn of civilization furnishes evidence conclusive that property alone was capable of furnishing an adequate motive for the overthrow of this system and the substitution of the descriptive. There are strong reasons for believing that the remote ancestors of the Aryan, Semitic, and Uralian families possessed the classificatory system, and broke it up when they reached the family state in its present sense.

Upon this family, as now constituted, modern civilized society is organized and reposes. The whole previous experience and progress of mankind culminated and crystallized in this one great institution.

It was of slow growth, planting its roots far back in the ages of barbarism, — a final result, to which the experience of the ages had steadily tended. The family, which in this view of the case is essentially modern, is the offspring of this vast and varied experience of the ages of barbarism.

Since the family was reached, it has also had its stages of progress, and a number of them. The rise of family names, as distinguished from the single personal name common in barbarous nations, is comparatively modern in the Aryan family. The Roman GENS is one of the earliest illustrations. This people produced the triple formula to indicate the *name of the individual*, of the *Gens* or *great family*, and of the *particular family* within the *Gens*. Out of this arose, in due time, the doctrine of agnation, to distinguish the relationship of the males, who bore the family name, from that of the females of the same family. Agnatic relationship was made superior to cognatic, since the females were transferred, by marriage, to the families of their husbands. This overthrew the last vestige of tribalism, and gave to the family its complete individuality.

15. The Overthrow of the Classificatory System of Relationship and the Substitution of the Descriptive. — Without attempting to discuss the fragments of evidence tending to show that the Aryan, Semitic, and Uralian families once possessed the classificatory system, it will be sufficient to remark, that, if such were the fact, the rights of property and the succession to estates would have insured its overthrow. These are the only conceivable agencies sufficiently potent to accomplish so great a change. Without such a change the family, as now constituted, would have remained impossible.

In conclusion I may remark, that the probable truth of this solution cannot be fully appreciated from the limited presentation of the facts contained in this article. At most it will but serve to invite attention to the great sequence of customs and institutions which seem to mark the successive stages of man's progress through the periods of barbarism, and to indicate the intimate relations which this remarkable system of consanguinity appears to sustain to the condition, experience, and advancement of mankind during the primitive ages. The manuscript containing the body of the evidence is now in course of publication by the Smithsonian Institution.

Five hundred and ninety-second Meeting.

March 10, 1868. — ADJOURNED STATUTE MEETING.

The PRESIDENT in the chair.

The President called the attention of the Academy to the recent decease of Sir David Brewster of the Foreign Honorary Members, and of Hon. Daniel Lord, of New York, of the Associate Fellows.

Five hundred and ninety-third Meeting.

April 14, 1868. — MONTHLY MEETING.

The PRESIDENT in the chair.

The President called the attention of the Academy to the recent decease of Dr. Samuel L. Dana, of the Resident Fellows, and of Professor William Smyth, of the Associate Fellows.

The following paper was presented: —

*Dispersion of a Ray of Light refracted at any number of Plane Surfaces.** By EDWARD C. PICKERING.

LET $a_1\ a_2\ a_3$, &c., be the angles included between the surfaces, $n_1\ n_2\ n_3$ their indices of refraction, $i_1\ i_2\ i_3$ the angles of incidence, $r_1\ r_2\ r_3$ the angle of refraction; $\sin i_1 = n_1 \sin r_1$ and in general

$$\sin i_m = r_m \sin r_m \tag{1}$$

also

$$i_m = a_{m-1} + r_{m-1} \tag{2}$$

As the dispersion of any portion of the spectrum is always proportional to the angular divergence of two rays of nearly equal refrangibility, if we vary $n_1\ n_2$, &c., dr_m will measure the dispersion. Differentiating (1)

$$\cos i_m\, di_m = r_m \cos r_m\, dr_m + \sin r_m\, dn_m$$

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* Since presenting this communication to the Academy, I have learned that a portion of this subject was studied by Sir David Brewster in 1812. I have, therefore, modified my paper, omitting what was not new, except when necessary to preserve the context.

if $n_1\, n_2\, n_3$ are all functions of N, making the latter the independent variable and dividing by dN, we have

$$\frac{dr_m}{dN} = \frac{\cos i_m}{n_m \cos r_m} \frac{di_m}{dN} - \frac{\sin r_m}{n_m \cos r_m} \frac{dn_m}{dN} \qquad (3)$$

But differentiating (2)

$$di_m = dr_{m-1}$$

and calling

$$\frac{\cos i_m}{n_m \cos r_m} = a_m, \quad \frac{\sin r_m}{n_m \cos r_m} \frac{dn_m}{dN} = b_m$$

also the dispersion of a ray after passing m surfaces, or

$$\frac{dr_m}{dN} = l_m,$$

and (3) becomes

$$l_m = a_m\, l_{m-1} - b_m \qquad (4)$$

This formula by successive substitutions may be applied to any case. For a single surface

$$m = 1, l_o = 0,$$

and hence

$$l_1 = a_1\, 0 - b_1 = -\frac{1}{n_1} \text{ tang } r_1$$

which equals unity when tang $r_1 = n_1$ or at the angle of total polarization. That is, the unit of dispersion is that produced by a single surface when the ray is in the position of total polarization. For two surfaces (4) becomes

$$l_2 = a_2\, l_1 - b_2 = -\,(a_2\, b_1 + b_2)\,;$$

in a prism $n_2 = \frac{1}{n_1}$ making suitable substitutions, and reducing we obtain

$$l_2 = \frac{\sin a}{\cos r_1 \cos r_2}$$

a being the angle of the prism. For minimum deviation

$$r_1 = \frac{a}{2}, \quad r_2 = i_1 \text{ and } l_2 = \frac{2}{n} \text{ tang } i\,;$$

this does not, however, give the minimum of dispersion for which the condition (found by differentiating) is

$$n^2 \sin (a + r_1) \cos (a + 2 r_,) + \sin r_1 = 0 \qquad (5)$$

an equation which has, I believe, never been solved. When a is very small

$$\sin (a + r_1) = a + r_1, \cos (a + 2 r_1) = 1 \sin r_1 = r_1$$

since r_1 is small also, and (5) becomes

$$n^2 (a + r_1) + r_1 = 0\,; \; r_1 = a \frac{n_2}{n_2 + 1'}.$$

I find that this equation gives very nearly the true value of r_1, even when a is large, thus for $n = 1.5$, $a = 15°$, 30°, 45°, and 60° it gives $r_1 = 10° 23'$, 20° 46', 31° 9', and 41° 32', while the true values obtained by trial in (5) were 10° 23', 20° 45', 31° 6' and 41° 29'.

To show the comparative deviation and dispersion, while a prism is rotated, I have calculated the following table for prisms whose index of refraction is 1.5, and their angle 15°, 30°, 45°, and 60°; r_2 is the angle at which the light leaves the prism, and i_1 that at which it enters. The columns headed "Reduced Deviation" are calculated by the condition that for small angles at which the dispersion and deviation are proportional their units shall be the same.

From this table it follows that if we turn the prism of a spectroscope 20° from minimum deviation, the dispersion will be nearly doubled, thus doubling the power of the instrument. In projecting the spectrum on the screen, this device is often useful; I have thus, by a single 60° prism, projected a spectrum of such a size that the two parts of the *D* line were about a millimetre and a half apart, each having a thickness of only about half a millimetre.

Since the dispersion does not depend strictly upon the deviation, and we may have two prisms producing the same dispersion but unequal deviations, we can evidently make one achromatize the other, even if they are made of the same kind of glass, and have the same angle. Thus if two 15° prisms be so placed that r_2 shall be 50° for one, and 37° 21' for the other, the dispersions of each will be .418, while the deviation will be 11° 7' for one, and 17° 53' for the other, as may be seen from the table. Again, if the ray of light passes through first one and

r_2	i_1	Deviation.	Reduced deviation.	Dispersion.	r^2	i_1	Deviation.	Reduced deviation.	Dispersion.
15° *Prisms.*									
° ′	° ′	° ′			° ′	° ′	° ′		
—42 35	90 0	32 25	1.131	.472	22 51	0 0	7 51	.272	.281
—40 0	76 18	21 18	.743	.443	30 0	6 42	8 18	.289	.300
—30 0	58 6	13 6	.457	.362	40 0	15 28	9 32	.332	.344
—20 0	45 6	10 6	.352	.312	50 0	23 53	11 7	.388	.418
—10 0	33 38	8 38	.302	.283	60 0	31 18	13 42	.478	.552
0 0	22 51	7 51	.274	.268	70 0	37 13	17 47	.616	.827
6 56α	15 41	7 37	.265	.265	80 0	41 11	23 49	.831	1.658
10 0	12 35	7 35	.264	.265	85 0	42 13	27 47	.970	3.354
11 17β	11 17	7 34	.264	.266	90 0	42 35	32 35	1.131	∞
20 0	2 44	7 44	.270	.276					
30° *Prisms.*									
—17 53	90 0	42 7	1.470	.705	40 0	6 57	16 57	.592	.655
—10 0	63 34	23 34	.822	.633	48 35	0 0	18 35	.648	.756
0 0	48 35	18 35	.648	.577	50 0	1 3	18 57	.655	.778
10 0	36 30	16 30	.576	.559	60 0	7 55	22 5	.761	1.000
13 56α	32 8	16 4	.561	.551	70 0	13 15	26 45	.934	1.480
20 0	25 43	15 43	549	.556	80 0	16 42	34 18	1.197	2.934
22 51β	22 51	15 42	.548	.562	85 0	17 35	37 25	1.306	5.857
30 0	15 55	15 55	.556	.587	90 0	17 53	42 7	1.470	∞
45° *Prisms.*									
0 0	imag.			1.000	40 0	30 16	25 16	.882	.980
4 47	90 0	49 47	1.738	.952	50 0	21 45	26 45	.934	1.135
10 0	68 33	33 33	1.171	.919	60 0	14 40	29 40	1.036	1.435
20 0	52 16	27 16	.952	.885	70 0	9 20	34 20	1.198	2.080
21 7α	50 47	26 54	.938	.885	80 0	5 57	40 57	1.429	4.080
30 0	40 17	25 17	.882	.905	85 0	5 5	45 5	1.571	8.127
35 2β	35 2	25 4	.875	.934	90 0	4 47	49 47	1.738	∞
60° *Prisms.*									
27 55	90 0	57 55	2.022	1.315	50 0	47 14	37 14	1.300	1.545
28 27α	83 35	52 2	1.816	1.315	60 0	38 52	38 52	1.356	1.907
30 0	77 7	47 7	1.645	1.317	70 0	32 53	42 53	1.496	2.716
40 0	58 29	38 29	1.343	1.374	80 0	29 12	49 12	1.717	5.273
48 35β	48 35	37 10	1.297	1.511	90 0	27 55	57 55	2.022	∞

α Minimum of Dispersion. β Minimum of Deviation.

then the other, the second will neutralize the dispersion of the first, while there will remain $17° 53' - 11° 7' = 6° 46'$ deviation. It was by this arrangement of prisms that Brewster obtained achromatism with one kind of glass.

Perhaps the most important application of these principles is to photographing the spectrum. Photographs taken by the common methods are greatly distorted, particularly in the more refrangible end. They

can only be used by identifying the more prominent lines, with those whose wave-length is known, and interpolating the remainder approximately. If, as is often the case, these standard lines cannot be recognized, the photograph becomes useless. To show the amount of distortion, suppose a spectrum to contain three similar double lines A, B, and C, whose indices of refraction are 1.5, 1.6, and 1.7, and that we use a 60° prism, the line B being in the position of minimum deviation. The deviations of the three lines will then be 48° 34′, 53° 8′, and 58° 11′, and their dispersion 1.528, 1.667, 1.878; that is, A and C will be at distances of 4° 34′ and 5° 3′ from B instead of equidistant, and the interval between the components of each line will be as 1.528 : 1.667 : 1.878; the distortion in this case amounting to about 20 per cent.

If now the portion of the screen which receives the line C be brought nearer the prism, the parts of this line will approach one another, and since their distance apart is proportional to their distance from the prism, the three lines will appear alike, if the screen is so inclined that the points where they are projected are at distances,

as $$\frac{1}{1.528} : \frac{1}{1.667} : \frac{1}{1.878}$$

or as $$.654 : .600 : .532.$$

A simple calculation shows that the screen must be slightly curved to fulfil this condition, but if plane, the distortion will be only about one and a half, instead of twenty per cent, the angle of inclination with the ray B being about 37°. If an achromatic lens was used for the projection, all parts of the spectrum would not be in focus, but with a single lens the focal distance of the violet is always less than that of the red rays. If then we use such a lens, inclining the screen at the same time corrects the distortion, and brings all parts into focus at once. By placing the prism at a suitable distance from the lens, both sources of error may be almost entirely eliminated. The oblique incidence of the light on the sensitive surface would be an objection to this method, but would be partly counterbalanced by the fact that the length of the spectrum would be thereby increased more than one half. Or, if preferred, the prism may be turned, so that, applying the correction for distortion as above, the screen shall be more nearly perpendicular to the light.

In conclusion, this spectrum would possess the following advantages

over the distorted forms now in use. Horizontal distances being proportional to the change in the index of refraction, the latter could be determined at once for any line, by a scale of equal parts. Its extent would be much greater than that of the visible spectrum, and we could determine the index of refraction of rays of too short wave-length to be measured readily by the common methods. It would be a normal spectrum for any given material, being independent of the form and position of the prism. And (especially if the interference bands were produced in it) it would afford, from its extent, great advantages for the study of the laws of the dispersion of light by different substances.

Five hundred and ninety-fourth Meeting.

May 12, 1868. — Monthly Meeting.

The President in the chair.

The Corresponding Secretary read letters relative to exchanges; also a letter from Professor De La Rive in acknowledgment of his election into the Academy as a Foreign Honorary Member.

Mr. C. M. Warren presented by title a memoir on "Volatile Hydrocarbons in Pennsylvania Petroleum."

DONATIONS TO THE LIBRARY,

FROM JUNE 2, 1865, TO JUNE 30, 1866.

State of Massachusetts.

Report to His Excellency the Governor and the Honorable Council, of the Commissioners appointed under the Resolve of May 3, 1865, "concerning the Obstructions to the Passage of Fish in the Connecticut and Merrimack Rivers." 8vo pamph. Boston. 1866.

Massachusetts Historical Society.

Proceedings. 1864-1865. 8vo. Boston. 1866.

Massachusetts Institute of Technology.

First Annual Catalogue of the Officers and Students, and the Programme of the Course of Instruction, of the School of the Massachusetts Institute of Technology. 1865-66. 8vo pamph. Boston. 1865.

Boston Society of Natural History.

Proceedings. Vol. IX., X. 8vo. Boston. 1865-66.

Condition and Doings of the Boston Society of Natural History, as exhibited by the Annual Reports of the Custodian, Treasurer, Librarian, and Curators. May, 1865. 8vo pamph. Boston. 1865.

Trustees of the Public Library of the City of Boston.

Thirteenth Annual Report of the Trustees, 1865. 8vo pamph. Boston. 1865.

Boston Athenæum.

List of Books added to the Library of the Boston Athenæum, from December 1, 1864, to December 1, 1865. 8vo pamph. Boston. 1865.

Observatory of Harvard College.

Report of the Committee of the Overseers of Harvard College, appointed to visit the Observatory, in the Year 1864. Together with the Report of the Director. Submitted March 8, 1865. 8vo pamph. Boston. 1865.

Director of the Museum of Comparative Zoölogy.

Illustrated Catalogue of the Museum of Comparative Zoölogy at Harvard College. Published by Order of the Legislature of Massachusetts. No. I. Ophiuridæ and Astrophytidæ. By Theodore Lyman. No. II. North American Acalephæ. By Alexander Agassiz. 2 vols. 4to. Cambridge. 1865.

Annual Report of the Trustees of the Museum of Comparative Zoölogy. Together with the Report of the Director, 1865. 8vo pamph. Boston. 1865.

Essex Institute.

Proceedings. Vol. IV. 8vo. Salem. 1866.

An Historical Notice of the Essex Institute; with the Act of Incorporation, Constitution and By-Laws, and Lists of the Officers and Members. 8vo pamph. Salem. 1865.

Naturalists' Directory. Part I. North America and the West Indies. 8vo pamph. Salem. 1865.

American Antiquarian Society.

Proceedings of the American Antiquarian Society at a Special Meeting, January 17, 1865, in reference to the death of their former President, Hon. Edward Everett. 8vo pamph. Boston. 1865.

Proceedings at the Semiannual Meeting held in Boston, April 26, 1865. 8vo. Boston. 1865.

Proceedings at the Annual Meeting held in Worcester, October 21, 1865. 8vo. Cambridge. 1865.

Proceedings at a Special Meeting, March 16, 1866, and at the Semiannual Meeting at the Hall of the American Academy in Boston, April 25, 1866. 8vo. Cambridge. 1866.

American Oriental Society.

Journal. Vol. VIII. No. 2. 8vo. New Haven. 1866.

Editors of the American Journal of Science and Arts.

Journal. N. S. Vol. XL., XLI. 8vo. New Haven. 1865-66.

Lyceum of Natural History of New York.

Annals. Vol. VIII. Nos. 2-7. 8vo. New York. 1864-66.

Mercantile Library Association of the City of New York.

Forty-Fourth Annual Report of the Board of Directors, May, 1864 - April, 1865. 8vo pamph. New York. 1865.

Catalogue of Books in the Mercantile Library of the City of New York. 8vo vol. New York.

Mercantile Library Association of the City of Brooklyn.

Seventh Annual Report of the Board of Directors, March 30, 1865. 8vo pamph. Brooklyn, N. Y. 1865.

The Trustees.

Forty-First Annual Register of the Rensselaer Polytechnic Institute, Troy, N. Y., for the Academical Year 1864-65. 8vo. Troy, N. Y. 1865.

American Philosophical Society.

Transactions. N. S. Vol. XIII. Pt. I., II. 4to. Philadelphia. 1865.

Proceedings. Vol. X. No. 73, 74, 75. 8vo. Philadelphia. 1865-66.

Academy of Natural Sciences of Philadelphia.

Proceedings. 1865. No. 2, 3, 4, 5. 1866. No. 1. 8vo. Philadelphia.

Philadelphia College of Pharmacy.

American Journal of Pharmacy. 3d Ser. Vol. XIII., XIV. 8vo. Philadelphia. 1865-66.

Mercantile Library Company of Philadelphia.

Forty-Third Annual Report. January, 1866. 8vo. Philadelphia.

Smithsonian Institution.

Annual Report of the Board of Regents, showing the Operations,

Expenditures, and Condition of the Institution for the Years 1863-64. 2 vols. 8vo. Washington. 1864-65.

Library of Congress.

Catalogue of Additions made to the Library, from December 1, 1864, to December 1, 1865. 8vo. Washington. 1865.

Patent Office, Washington.

Report of the Commissioner of Patents for the Year 1861. Vol. I., II. 1862. Vol. I., II. 1863. Vol. I., II. 8vo. Washington. 1863-66.

Bureau of Navigation.

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